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(now the Royal Asiatic Society of Bengal) to arrange for the holding of a Science Congress in Calcutta in January 1913. Various difficulties, however, necessitated the postponement of this meeting until January 1914. The arrangements for the meeting were in the hands of the Royal Asiatic Society of Bengal, and thus commenced an association to which the Congress undoubtedly owes much of its success. The organization of the Congress has followed closely that of the British Association although, in view of their special importance in India, sections of medicine and veterinary science were included.

The numbers attending the first meeting, when the late Sir Asutosh Mukherjee, vice-chancellor of the University of Calcutta, was president, were small; some thirty scientific communications were read, mainly by authors resident in Calcutta or its vicinity. This appeared to justify the critics of the scheme who had suggested that geographical difficulties would preclude its success. However, the Government of India early recognized the potential value of the Congress and authorized the payment of expenses to selected Government servants. As a result, the second meeting, in Madras in 1915, was more largely attended and communications were received from authors as far distant as the Punjab and Ceylon. Since these early days, the Congress has grown very greatly, as shown by the size of the *Proceedings*, which in 1914 filled six pages and in 1928 four hundred and twenty.

Whilst this increase in the number of communications read to the various sections provides evidence of the growth of scientific inquiry in India, the main success of the Congress has been, as the original promoters had hoped, in the social contacts which it has provided and the public interest in science which it has aroused in the various centres it has visited. It has stimulated also the formation of such specialist societies as the Indian Botanical Society and the Indian Chemical Society.

While substantial progress in both teaching and research has been made by the universities of India, their responsibilities—and with them those of the Indian Science Congress Association—must inevitably increase. In this present scientific age, efforts are everywhere being made to develop natural resources to the utmost, to improve industrial processes and to increase our knowledge in pure science. It is to the universities and technical institutions that we must look for men to carry out this work. The universities must be able, not only to give instruction, but also to select those who are to be trained in the methods of research. From the latter we may expect to obtain future leaders of research, on whom the prosperity of the country will largely depend.

The utilization of science implies, moreover, a planned scheme of research. Here the experience of some of the Overseas Dominions may prove of service to India. In Canada and in Australia, there are State or Provincial Governments as well as a Federal Government, and in both cases it has been found expedient that the research organization of the country should be truly national and responsible to the Federal Government alone. Even in an Empire the size of India, where the resources and needs of various provinces are widely different, it would seem that centralized organization of research is the only way of avoiding waste of money and effort. The detailed planning of research must be in the hands of those with the necessary specialized knowledge, and they must be able to act without suspicion of political or racial influence. Here the Indian Science Congress Association has shown, over a long period of political turbulence, what can be accomplished, for a marked feature of the Congress has been the complete absence of racial and communal strife; it has remained quite unaffected by these tragic influences, doubtless due in part to the tact of the various general officers and to the very valuable services of the secretary of the Royal Asiatic Society of Bengal, Mr. J. van Manen.

Since the foundation of the Indian Science Congress Association, it had always been hoped that it might prove possible to arrange for an over-seas visit of the British Association to India. The necessity, for climatic reasons, of holding such a meeting during the cold weather (November to February), the middle of the academic year, offered serious difficulties. However, they have now been overcome, and, moreover, the precedent has been established of sending a delegation to a joint meeting with another organization. This is undoubtedly of great significance. Valuable as are personal contacts within a country, such contacts with workers in other countries and the opportunity of seeing the conditions under which they work are of even greater value, while the presence of a body of distinguished scientific visitors in India cannot fail to be a source of inspiration to students and scientific investigators in that country.

Medicine as a State Service

Socialised Medicine in the Soviet Union
By Dr. Henry E. Sigerist. Pp. 382. (London: Victor Gollancz, Ltd., 1937.) 15*s.* net.

DR. HENRY SIGERIST was the successor of his great master Sudhoff as professor of the history of medicine at Leipzig, and now occupies a similar post at Johns Hopkins University, Baltimore. He is a prolific writer of popular books on historical subjects related to medicine, and many readers of NATURE will know his books on "Man and Medicine" and his biographical account of "Great Doctors". He has now embarked upon a survey of the medical policy of the Soviet Union, of which he appears to be a warm admirer. Indeed, it is not too much to say that he is something more than favourably disposed, and this should be borne in mind in weighing his evidence. Sidney Webb, well known as an advocate of Soviet policy, furnishes a foreword to the book, and concurs in Prof. Sigerist's view that the Soviet method is planned throughout on a scientific basis. It banks on science for its salvation. As Sidney Webb says elsewhere (1937),

"it refuses to accept as knowledge or as the basis of its code of conduct any of the merely traditional beliefs and postulates about man and the universe for which no rational foundation can be found, or any of the purely subjective imaginings of the meta-physician or the theologian".

Prof. Sigerist vigorously criticizes what he calls the 'compromise system' of the capitalist countries in respect of medicine. State medicine, he says, insurance medicine, charity medicine and private medicine exist side by side. The fight against disease is not planned, not led by one general staff; it is without design, and with all the deficiencies of a compromise. In other words, it has grown, in response to need, over the centuries, charity medicine (or medical alms-giving), organized private practice, a public health service, health insurance—which is the more correct order of events—emerging as "individualism" and becoming more fully organized as the community requires. Dr. Sigerist finds this historical process unsatisfactory, and prefers the Soviet model. The Soviet health system is described in these words:

"(1) Medical service is free, and therefore available to all, (2) the prevention of disease is in the foreground of all health activities, (3) all health activities are directed by central bodies, the People's Commissariats of Health, with the result that (4) health can be planned on a large scale."

This definition is clear, and not unappetizing, but to the ancient world (which, *inter alia*, is England) it has, at first sight, the appearance of one more top layer super-added to the palimpsest. In the author's view, shared presumably by everybody, this plan can only be that of a Marxist socialist State. He claims if a society is to function successfully it requires healthy members; to obtain them health must be accessible to all, and free of charge. Medicine, like education, must be, he says, not a trade but a public function of the State.

"The great majority of the population (74 per cent in 1934, more to-day) consists of wage-earners and collective farmers. The wage-earners receive their wages from the State as all enterprises are State enterprises. The collective farmers sell their crops to the State. Both groups purchase whatever they buy from the State. All money goes therefore from the State to the population and back to the State, which redistributes it every year. In the course of production, surplus values are created which are controlled and distributed by society through its various agencies. Part of this surplus serves to finance the health work of the nation."

The scheme begins with the most complete social insurance system, the costs of which are part of the cost of production; the health work is operated and controlled by the Commissariats of Health and their subordinate organs, at the cost of insurance surplus and the local central budgets; the system is designed to be preventive, and "prophylaxis is in the foreground of all medical considerations"; the Soviet medical man is not a private practitioner but a civil servant, a citizen and a worker, and all his actions are for the benefit of society; a Scientific Medical Council advises the Commissariat in all medical matters, distributes the doctors and differentiates their work, and organizes research.

"The State has but one purpose, to promote the welfare of the people, of all the people, without distinction; to raise the material and cultural standard of the population; to liberate man from the bonds of poverty, of ignorance and disease. This and only this justifies the existence of the State."

In the Soviet Union, where physicians work on a salary basis, fees and the money issue are eliminated. Medical service is given through health centres of various kinds, dispensaries, polyclinics, ambulatoria, preventoria, prophylactoria, or hospitals. Certain groups are especially provided for, such as labour or mothers and children, and these are often dealt with at the

factory clinic or at the school. For bed cases institutional treatment is available. Physical culture and recreational exercise are encouraged and provided for. Convalescent homes and popular resorts are developed, as also are housing reform and food supply, all on a more or less communal basis. Social diseases (tuberculosis, venereal, prostitution, abortion) are especially dealt with, and as they are common a large and elaborate organization has been set up. In 1920, as is well known, the Soviet Government legalized abortion and the practice spread rapidly, but in 1936 a law was passed making abortion a criminal offence, and providing new facilities for maternity, infants' nurseries and family allowances.

Neither Dr. Sigerist nor anyone else can say how this vast experiment will turn out. Indubitably it is favoured by the mass of the population, and in the cities is bringing a measure of health never known before in Russia. Apart from the wild scheme of encouraging abortion, maternity and childhood are safeguarded, insurance is more complete than elsewhere, and abundant amenities are brought to a people accustomed to few or none. It is too early to consider vital statistics. The imposition of so huge a medical scheme, varied and costly, inelastic and continually being altered, at such incredible speed, would seem to be courting disaster, yet it is being accepted by a communistic world. As for the future, Dr. Sigerist is sanguine and confident. He has certainly produced the most interesting book which has yet been written on the organization of medical science in Russia. This is not the occasion to explain the cogent reasons why the Soviet system of State Medicine cannot be adopted in Britain, though we should be wise to learn from it what we can.

GEORGE NEWMAN.

Chemistry of the Cell Wall

The Biochemistry of Cellulose, the Polyuronides, Lignin, etc.
By Dr. A. G. Norman. Pp. ix + 232. (Oxford: Clarendon Press; London: Oxford University Press, 1937.) 15*s.* net.

DR. A. G. NORMAN has done a real service to an increasing number of research workers by putting together the literature relating to the very complex group of compounds which constitute the cell wall of plants. The field is a developing one of scientific interest and technical importance, the established facts are few and somewhat scattered, whilst the literature retains much that is unsound. He is not afraid to give a lead at times in being both critical and trying to give the right perspective: in our opinion the book forms a platform from which future work can be initiated on sounder lines than in the past, and as such should be widely and carefully read.

Cellulose has been closely studied by chemists, who have cleared up most of its structural problems: there is a controversy as to whether its chain of glucose molecules joined end to end is a mere one to two hundred units long, as postulated by the Birmingham School, or whether it is ten times greater in length as is even more widely held and is indicated by physical measurements. Prof. W. N. Haworth gets out of the difficulty by joining his molecules together by co-ordination valencies, whereas the opponents do not see any reason to discard chemical valencies: it is considered that Haworth worked with an already degraded cellulose.

It is a moot question whether any of these large molecules can be properly considered as defined chemical entities. In the cell, where they have visible structure, the aggregate number of unit molecules is a very large one; probably the attempts to transfer the substance from the cell to the laboratory flask result in its simplification. Indeed, if the process be carried too far, there is a definite change in physical property, as, for example, loss of tensile strength in a degraded cotton, which has been proved to have a shorter average chain-length.

Cell wall chemistry would be relatively simple if glucose were the only sugar elaborated by the plant. In fact, it produces also galactose and mannose, which are isomeric with glucose, also two pentose sugars, xylose and arabinose, and possibly still other of the many isomeric sugars that are theoretically possible but which are difficult to identify. In addition, there are the uronic acids, which apparently make up the whole molecule of pectin and can be regarded as the half-way stage between the hexose and pentose sugars: it is considered that xylose is made from glucose in the plant and is not a product of original synthesis. The process involving oxidation followed by decarboxylation has so far baffled observation, and therefore particular interest attaches to recent work of Campbell in which he has obtained carbohydrates from wood and from oak leaves, representing as it were a transition stage between starch and the mixed polysaccharides.

In studying such substances the initial difficulty is to obtain them sufficiently free from similar compounds to make them worth analysis and at the same time not to break them down during the process of purification. Where this has been accomplished, results have begun to accrue which are startling in the sense that they disclose a greater complexity of structure than might perhaps have been expected. Whereas in cellulose, as also in starch, the end carbon of one little six carbon chain-molecule of glucose is joined to the fourth carbon from the end of the next glucose, it is found with the so-called hemi-celluloses that the join is to the sixth carbon and sometimes to the fifth carbon.

Whilst the natural syntheses are definitely selective and no doubt catalysed by an enzyme, it is clear that many alternative syntheses which the chemist can picture on paper also take place under other conditions and give rise to substances which though closely similar are intended to meet other functional ends.

Incidentally, the term hemi-cellulose is unfortunate, as these compounds are in no sense degradation products of cellulose or even related to it: the author suggests the term amylo-uronides in substitution.

It is possible only to indicate a few of the problems covered by the book: it also includes a chapter dealing with lignin, a polymeric material containing an aromatic group on which much work is still to be done. E. F. A.

Babylonian Mathematics

Mathematische Keilschrift-Texte

Herausgegeben und bearbeitet von O. Neugebauer. Teil 3: Ergänzungsheft. (Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik, herausgegeben von O. Neugebauer und O. Toeplitz, Abteilung A: Quellen, Band 3.) Pp. vi + 83 + 6 plates. (Berlin: Julius Springer, 1937.) 26.60 gold marks.

THIS Part 3 of the volume of mathematical cuneiform texts forming vol. 3 of Section A of the "Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik", though only supplementary to Parts 1 and 2, published in 1935, is a substantial volume of more than 90 large quarto pages, and contains additions and corrections necessary to make the volume complete. It includes texts which have become known to the editor since 1935 and revisions of a number of the texts which were included in the earlier parts, but could not then, owing to illegibility or otherwise, be dealt with more than provisionally.

In the meantime, other workers in the same field have been active; the first text, that of British Museum No. 13901, was first published by Thureau-Dangin in 1936; the second (B.M. 34568) was almost entirely contributed by Waschow; the third in Chapter i, one of the texts of the Yale Babylonian Collection (Y.B.C. 6504), was first recognized as mathematical by A. Götze, and F. J. Stephens helped in preparing the text. Chapter ii contains improved texts of the inscriptions belonging to the Yale collection mostly included or mentioned in Part 2; chapter iv (15 pages) is important, giving many additions and corrections to Parts 1 and 2. There are substantial improvements, again owing much to the labours of Thureau-Dangin, Waschow, O. Becker, Kurt Vogel, Bartolotti and others. Chapter v gives a complete glossary to the texts dealt with in chapters i to iii and additions and corrections to the glossary in Part 2; in chapter vi we have observations on the general character of the Babylonian achievements in mathematics, with fresh indications of their nature furnished by astronomical texts. Special attention should be directed to chapter vii, containing indexes, the last of which is a "Sachregister", or index to the subject-matter, of all three parts. Such an index is absolutely indispensable in a work of this kind; and the present one does not fail us.

The editor seeks to show that, not only in astronomy, but also in the purely mathematical domain, there existed, in addition to the texts which we have, and which contain multitudes of examples worked out on uniform lines but without any statement of general rules, works containing such rules and deserving to be described as 'text-books'. This view is, he thinks, supported by one or two passages where we are told what to do in general terms, as in the following case from B.M. 34568: "Take (*a*) the sum of the length, breadth and diagonal and (*b*) twice the area. Subtract the latter from the square of the former. Take the half of the remainder", and so on. These cases may indicate that there existed formulæ for solution stated generally and not merely in the concrete numbers of a particular case; but it still seems that we look in vain for any indication how the formula was arrived at, and for anything of the nature of a *proof* of its correctness.

Among details calling for notice are the following: (1) The consideration of the text of B.M. 13901, which goes back to the Hammurapi period, shows that it deals with the same type of problem as what the editor calls "Serientexte", which must therefore go back to the same period (1955–1913 B.C.), although the surviving examples of the series are somewhat later in date. Again, another B.M. text of the Seleucid period (321–64 B.C.) has an example exactly analogous to one which is more than a thousand years earlier. (2) The terminology for negative quantities (as such) can also be traced back to the earliest times. These things suggest that there was a continuous tradition all through the interval. (3) There is a problem in Part 2 about compound interest, in which it is required to find the period in which a capital sum accumulating at 20 per cent interest will double itself. The answer was given, but it was not clear how it would be arrived at. The mystery would now appear (p. 63) to be perfectly cleared up. It would be seen from exponential tables that the period is between three and four years; it is now shown that the working is consistent with the assumption that the time by which the period falls short of four years was obtained by the process of "linear interpolation".

T. L. H.

Hydroxides and their Applications

Hydroxyde und Oxyhydrate

Von R. Fricke und G. F. Hüttig. (Handbuch der allgemeinen Chemie, herausgegeben von Paul Walden, Band 9). Unter Mitwirkung von H. Zocher und Hj. Saechtling. Pp. xx + 641. (Leipzig: Akademische Verlagsgesellschaft m.b.H., 1937.) 60 gold marks.

SINCE the time of Lavoisier, metallic oxides and their hydrates have played an important part in the development of chemistry, leading to the determination of atomic weights of elements by Berzelius and the enunciation of the periodic classification of elements by Mendeléeff and Lothar Meyer.

Metallic oxides either singly or in mixtures have been utilized as catalysts by Haber, Sabatier, Senderens, Bosch, Bergius, Mittasch, and others in ammonia synthesis, hydrogenation reactions and other industrial operations. In the chromatographic analysis for the separation of the plant pigments (Tswett), in the isolation of enzymes (Willstätter) and in the separation of carotinoids (Kuhn, Karrer), metallic oxides and hydroxides are being used. In the development of colloid science, sols and gels of oxides of metals and non-metals have taken a very prominent share. The adsorptive capacity of the silica, alumina and other oxides in the soil mainly controls the moisture retention and other properties of the soil.

Profs. Fricke and Hüttig, aided by Dr. Zocher and Dr. Saechtling, have done a useful piece of work in collecting and summarizing the literature on the subject in the work under notice. The book is divided into two main sections; in the first, the preparation and properties of almost all the oxides and their hydroxides (including those of rare earth metals) are described, along with the sols and gels obtainable from many of the oxides. The colloid chemistry of the well-known sols of the hydrated metallic oxides is fully discussed.

In the second section, a general account appears of the X-ray analysis of several oxides and hydrates, their ageing with time both in the solid state and in the colloidal condition, their vapour pressures, the velocity of their hydration, their solubility in alkalis, their thermochemical, magnetic and dielectric constants. The X-ray diagrams are well reproduced in the case of several hydroxides, and a summary of the crystalline characteristics and constants of seventeen hydroxides as derived from X-ray analysis is tabulated. The investigations on the phenomenon of ageing, including X-ray analysis, diffusion measurements, dialysis, potentiometric titrations, etc., are ably summarized. The hydration and dehydration of several oxides and hydroxides have been studied, notably by van Bemmelen, Zsigmondy, Bachmann, Willstätter, Hüttig, Fricke, Hackspill, Patrick, and others, and this important subject has been dealt with satisfactorily from different viewpoints. The thermochemical properties, specially the heat of hydration of numerous oxides and hydroxides, are tabulated. An adequate account of the magnetic properties of the metallic oxides and hydroxides and a brief summary of the dielectric constants of some hydroxide sols and their change with time form the last two chapters of the book.

As is expected in the case of handbooks of this type, there is an extensive bibliography of original papers. The subject matter is of interest not only from the academic point of view, but also because it has considerable industrial and practical use. Since Profs. Fricke and Hüttig and their collaborators have themselves made important contributions to the subject, the book is authoritative, and should prove useful to senior students, research workers, and teachers of chemistry.

N. R. DHAR.

My Friend Mr. Leakey

By J. B. S. Haldane. Pp. v+179. (London: The Cresset Press, Ltd., 1937.) 6*s*. net.

PROF. HALDANE here applies his imaginative and literary craftsmanship to the conquest of new worlds. His friend Mr. Leakey is the most lovable of magicians, with a finer sense of right and wrong than one had learned to expect of his profession, and with limitations—to his still exceptional powers—which are at once convincing and endearing. We can picture few greater joys than dinner with Mr. Leakey; should this note chance to reach Prof. Haldane's eye, perhaps he will relent and put the address of Mr. Leakey's flat (not 221*a* Baker Street, because it is quite near Haymarket) in the next edition—although we should not be surprised if it had to be in the next edition but one.

It must not be supposed that this book is a frivolous one. It is full of information of the kind that every active-minded reader wants: how to tell a caiman from a crocodile, the difference in display between the *Daily Mail* and the *Daily Herald*, the correlation between brain size and versatility, what a man-size—or rather woman-size—butterfly would look like, the physical properties of tungsten, the rivers and glaciers of London, and so on.

Of course we could not hope to understand all the ways of magicians and their friends. So perhaps we may never know why the rat-catching magnets were put in holes that had to be specially dug, instead of being put into the docks, which would surely have suited more than somewhat, nor why Mr. Leakey navigated south-eastward from London to get to India, when every Boy Scout knows that you should start off north of east, nor why he said that the beam wireless to Australia (the Rugby-Sydney axis as the other spell-binders would call it) went over Persia (shouldn't it be Iran?) when it really goes over Moscow, nor why Prof. Haldane chose "none were" instead of "none was" from the two forms which every Girl Guide knows to be permissible, nor why he said "Bortsch" when every Komsomol boy or girl knows that it sounds more like "Borstch".

We hope Prof. Haldane will write some more on afreets in Fleet Street.

Le milieu et la vie en commun des plantes

notions pratiques de phytosociologie. Par M.-A. Reynaud-Beauverie. (Encyclopédie biologique, Tome 14.) Pp. 238. (Paris: Paul Lechevalier, 1936.) 60 francs.

THIS comprehensive book is largely a compilation, based mainly on extracts from Braun-Blanquet's "Plant Sociology", as well as from other writings by the same author and those of Profs. J. Pavillard and P. Allorge. The book, which will be appreciated chiefly by French-speaking people, owing to the fact that "Plant Sociology" has not been translated into that language, is evidently intended to attract the intelligent amateur as well as those who are professionally interested in the subject.

Until comparatively recently, the activities of natural history societies have been mainly directed to collecting and naming specimens and compiling local lists of species. This has given rise to the popular view that "Le Botaniste est un Monsieur qui vient dans nos bois, dans nos prairies, cueille nos plus belles fleurs, les fait sécher entre deux feuilles de papier buvard où elles perdent leurs brillantes couleurs, et ensuite . . . il les insulte en latin". It is to be hoped that this book will help to broaden the outlook of, and suggest new lines of investigation to, those whose activities have hitherto been directed to the mere acquisition of collections as an end in itself. This should help to disperse the narrow conception of the nature of a botanist mentioned above.

All who are interested in the study of plants in their natural environment will find this book full of interest, but nowadays the subject is one which can be approached from so many angles that a good grounding in all branches of botany, and some knowledge of physics and chemistry, is desirable before the subject-matter of the book as a whole can be fully appreciated. That this is so will be realized from the diversity of subjects dealt with, which range from particulars of equipment for collecting plants to the influence of light, temperature and rainfall on vegetation, or the detection of nitrates in the soil. It is noteworthy that in the section dealing with the effect of light on vegetation the only methods described for measuring the light intensity in different habitats are those based on the use of sensitized paper. The application of the photo-electric cell for this purpose, which gives more accurate results, is not mentioned.

A fairly extensive bibliography is given at the end of each section of the book; but most of the references cited are French, although some English and German ones are included. The book ends with a short subject index.

With Camera and Notebook:

a Naturalist's Calendar (1938). Edited by Phyllis Barclay-Smith and Rudolf Zimmermann. Pp. 60. (London: M. C. Forrester, 1937.) 3*s*. 6*d*. net.

A CALENDAR which will sustain interest and give pleasure throughout the year is not easy to find; Shakespearian quotations have become stale, and the Aberdeen joke is satiating after the first hundred. Perhaps the nearest approach to general interest has been achieved by the landscape calendars published by various newspapers, but the idea of a naturalists' calendar on the present scale is a new and excellent one. Each week has its photograph, reproduced by fine-meshed half-tone block about 5 inches by 6 inches in surface, and its appropriate news item, and the fact that the photographers include Seton Gordon, Mortimer Batten, C. W. R. Knight, J. D. Rattar and K. Herschel, is a guarantee of the value of the pictures, scientifically and æsthetically. They are mostly of mammals, birds, insects and wild flowers, and although a few are from Continental examples all the species illustrated are members of the British fauna. Miss Barclay-Smith and Rudolf Zimmermann of Dresden are to be congratulated on the beauty and interest of the photographs they have chosen. The stranded jelly-fish, mistakenly identified as *Aurelia aurita*, appears to be an *Æquorea*.

The Sense of Hearing in Fish*

By Prof. K. von Frisch, University of Munich

THERE is an old dispute as to whether fish are able to hear or not. It has seemed improbable that they can. Three main reasons have been brought forward against it.

(1) A biological reason: most fish seem to be dumb; a sense of hearing would therefore not be of biological significance for them.

(2) An anatomical reason: the inner ear of mammals has two main functions. It is the organ of equilibrium and the organ of hearing. Perception of equilibrium is the function of the utriculus and the semicircular canals. It is not yet clear if the sacculus of mammals has to do with equilibrium or with hearing. At the sacculus we find the cochlea; it is generally supposed that the cochlea alone is the organ of hearing. Comparative anatomy shows that there is no cochlea in the inner ear of fish. We find only a cavity of the sacculus, the lagena (Fig. 1, *L*), which is supplied with a stone and macula just like the sacculus (*S*) and utriculus (*U*). It has been suggested that fish cannot hear because the organ of hearing is not yet developed.

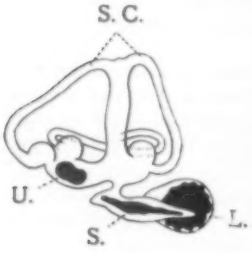

Fig. 1.

THE LABYRINTH OF A MINNOW. *U* = UTRICULUS; *S.C.* = SEMICIRCULAR CANALS; *S* = SACCULUS; *L* = LAGENA.

(3) The third reason against the acceptance of a sense of hearing in fish was a physiological one. Many investigators tried to clear up the matter by making experiments, but they could not observe any reaction of fish to sound. But on this point there is no agreement. For example, American investigators, especially Prof. Parker and his collaborators, made experiments with various fish with positive results. Opponents, especially in Germany, could not confirm it. It was argued that if there is a reaction to sound it would be a reaction to the movement of water and not to sound vibration—it would not be true hearing.

So the question arises: What is hearing? I think that, in vertebrates, it is not difficult to define it. Human beings can perceive very loud sounds by means of the skin and by means of the inner ear. Perception through the skin we call feeling; perception through the inner ear we call hearing. In all vertebrates the inner ear is a homologous organ. We should only speak about 'hearing' in the case of the perception of sound vibrations by means of the inner ear in vertebrates.

But the first question must be: Is there a reaction to sounds in fish? There was no agreement on this point. Many observers could not see any reactions to whistling, or to notes from a violin, or to the voice of a singer, and so on. But that is not astonishing. The voice of a singer or the sound of a violin or whistle is not of the slightest biological significance for fish. We should not wonder, therefore, if they do not react to it.

I thought, however, it might be possible to give a biological significance to sounds. If we whistle every time when we give food to the fish, then whistling acquires a biological significance, because the food is announced by it. First I performed the experiment in the following manner. I had a little catfish, *Amiurus nebulosus*, in an aquarium. It lay mostly in an earthenware pipe put on the bottom of the aquarium. The fish was blind, both eyes having been removed, and so it could not see what happened. It got the food from a glass feeding-rod. When the food was brought near the opening of the pipe the fish perceived the meat by means of its chemical sense, came out and swallowed the food. Then, every time I gave it food, I whistled with my lips. Thus I tried to train the fish to the whistling. After some days the fish came out when I whistled before I put the feeding-rod into the water, swam upwards and sought for the food; and always after that it could be called out by soft whistling not only from nearby but also from a considerable distance, for example, from the other side of a large room.

Later these experiments were continued by my collaborator, Dr. Stetter. He used various kinds of fish. The best results were given by our little minnows (*Phoxinus lævis*), and therefore they have been studied very thoroughly. To produce sounds tuning forks were generally used for low sounds and whistles for the higher ones. The sense of sight was eliminated by removal of the eyes. Then the fish was trained to a certain sound by four to five training feedings daily. After a few days the fish gives a very typical reaction to sound. The kind of reaction varies from individual to individual. When the sound is given, some fish dive down and snap for food on the bottom, others go up and snap on the surface, others stop and

* Substance of a lecture delivered at University College, London, on March 4, 1937.

snap vigorously on whatever spot they may be, but all snap and seek for food because they are accustomed to get the food when the sound is given. After a few seconds we put the feeding-rod into the water; the fish gets the food, and so the training is continued.

There is not the slightest doubt that there are clear reactions to sound. Further experiments by Dr. Stetter gave a great many results. It seems to me that three of them are of special interest.

Dr. Stetter tried to train fish to very low and to very high sounds, and so to find out the limits of the sense of hearing. The upper limit in minnows is between D^5 and A^5 (about 5,000–7,000 vibrations a second). Training to higher sounds is without results. There are slight individual differences; but there is a far greater difference between various species of fishes. Thus *Amiurus* gave positive results up to 13,000 vibrations a second. This is about the same upper limit as in human beings. Dr. Stetter was unable to find a lower limit. The lowest tuning fork, C_2 (frequency 16), gave good results.

A second result concerns the acuteness of the sense of hearing. A minnow was trained to E^3 (frequency 660). Then the sound of the whistle was diminished gradually to a very low intensity. The aquarium was put on a table in a long corridor and the soft whistle was given from farther and farther away in a series of experiments until reactions could no longer be obtained. Reactions could be obtained from a distance of about 200 feet. We ourselves could hear the whistle from that distance only as a very weak sound. But it is difficult to understand what this means, because we do not know to what extent the sound is weakened on entering the water. We therefore brought a large aquarium to the same spot and one of our students dived down and was tested in just the same manner as the fish. The experiment showed that our best fishes could hear as well as men in the aquarium, or even a little better than men. It was very surprising to us.

The third result concerns the discrimination of sounds. It is possible to prove that minnows can distinguish between different sounds. The following method was employed. A fish is trained to a certain sound, that is, the feeding sound. When there is a good feeding reaction, we introduce another sound one or two octaves higher or lower than the feeding sound. But at this sound no food is given, and if the fish begins to snap and seek for food, it is punished by a light blow with a glass rod. This other sound we call the warning sound, because it means a punishment. After some time of training, the fish gives the feeding reaction only to the feeding sound; to the warning sound it gives no reaction, or even a very distinct flight reaction to avoid the punishing blow. Now the interval between the two sounds can be gradually decreased, and thus we can find out what interval can be distinguished. Most fishes can easily be trained to distinguish between two sounds at an interval of one octave. The best fish could distinguish perfectly between the two sounds of a minor third, D^1/F^1 (frequencies 290 and 345).

During 1936, Dr. Wohlfahrt in our laboratory was able to improve these results by employing a new method. In the experiments of Dr. Stetter there was always a period of at least a quarter of an hour between the feeding sound and the warning sound. The fish, therefore, had to keep the sound in mind and decide by memory. It was clear from these experiments that the fish has some sense of absolute hearing—but not a very good one. Wohlfahrt gave short sounds so that they immediately followed one another, just like a trill. In this way he was able to show that minnows are able to distinguish even a half-tone interval.

Judging from all these results, it is very probable that there is a true sense of hearing in fishes. To be certain we must seek for the organ of perception.

Experiments have been published by Prof. Parker and his collaborators indicating that the inner ear especially has to do with hearing in fishes. Some observations seemed to show that the sacculus especially, or the lagena, would be the seat of the sense of hearing. But the results were not very convincing, because the methods employed to eliminate the sacculus and the lagena were not satisfactory. The method of training the fishes to sound, combined with careful operations, promised a clear result.

I removed various parts of the labyrinth in minnows. I tried first to remove the utriculus and the ampullæ and to leave the sacculus and the lagena intact. There is no difficulty in doing this. To perform the operation the fish is narcotized by means of a 0·5 per cent solution of urethane. As soon as the fish recovers from the narcotic we find that it has completely lost its sense of equilibrium. It lies on one side on the bottom of the aquarium, and when it swims it turns over and curves the body in a peculiar manner. Nevertheless, it is possible to train such fish to sounds as easily as normal ones. Training can be carried out in the same manner, in the same time, and within the same limits as in the case of normal fishes. There is not the slightest sign that the utriculus and the ampullæ have anything to do with the sense of hearing. They are only organs of equilibrium. It is more difficult to remove the sacculus and the lagena; but I have succeeded in doing this. It was very surprising to see that such fish, with both sacculi and lagenæ and their large otoliths removed, swim in perfect equilibrium. But it is

impossible to train them to sounds. Generally I did with each of them more than a hundred training feedings, but the fish gave no reactions to the sounds. Normal fish or fish only operated upon on one side gave reactions after five to fifteen training feedings. I carried out the experiment also in the following manner. I trained a normal fish to a sound. Then it was operated on on one side. The reaction was as clear as before. The fish was operated on on the other side, and then it was never possible to get any reactions.

All this applies only to sounds higher than *C* (frequency 130). The fish without sacculus and lagena can be trained to low sounds, if they are loud enough. It can even distinguish between different sounds in the low region as well as normal

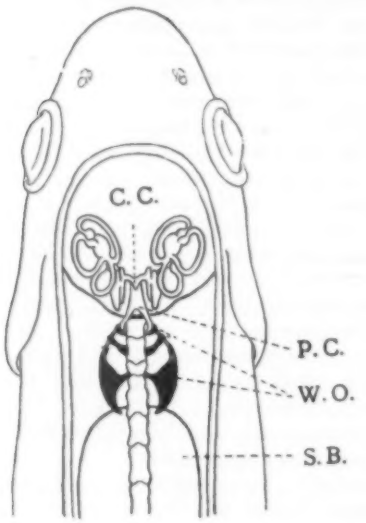

Fig. 2.

C.C. = CROSS CANAL, CONNECTING THE SACCULI WITH ONE ANOTHER; *P.C.* = POSTERIOR CAVITY; *W.O.* = WEBERIAN OSSICLES; *S.B.* = SWIM BLADDER.

fish. The low sounds are perceived as well as before, even if the whole labyrinth is taken away or if the sense organs of the lateral line, too, are fully destroyed. We can therefore assume that the low sounds are perceived through the skin.

From special experiments it can be concluded that the lowest sounds are perceived only with the skin, low sounds from frequency 25 up to about 130 with the skin *and* with the inner ear, and all the middle high and very high sounds from about frequency 130 up to the upper limit only with the labyrinth. That is more or less the same as in human beings.

It is stated above that minnows, in the region of middle high sounds, can distinguish between different sounds even when there is an interval of only half a tone. Now we know that these sounds are perceived by the sacculus and lagena. Thus we find that there is a remarkable ability to distinguish between different sounds in the fish labyrinth, in spite of the lack of a cochlea and therefore in the absence of a membrana basilaris. The function of the cochlea and of the membrana basilaris in higher vertebrates may be to improve the discrimination of sounds to the high degree known in man.

Certain anatomical facts are very important for understanding the acuteness of the sense of hearing in minnows. In minnows, as in all Cyprinids, there is a connexion between the labyrinth and the swim bladder by means of the Weberian ossicles. The sacculus of the right and left labyrinths are connected with one another by a cross canal (Fig. 2, *C.C.*) with a posterior cavity behind the labyrinth (*P.C.*) with one opening on each side. The opening is closed by a little bone connected with other bones by articulation (*W.O.*), the last of which is fixed to the anterior end of the swim bladder (*S.B.*). Sound vibrations in water must be transmitted to the swim bladder, from the swim bladder by means of the little bones to the cavity, from there to the cross canal and thence to the sacculus. Now it is very interesting that the shape of the otolith of the sacculus seems to make it suitable to take up the vibrations coming from the cross canal—a fact first recognized by the Dutch worker, Prof. de Burlet, in *Amiurus*.

We want to know, however, whether this connexion is necessary for sound perception. Consequently I took away the swim bladder through an incision in the ventral body wall of the minnow. I closed the wound by a suture and after recovering the minnows could be trained to sounds as before. But the acuteness of the sense of hearing was very much reduced. It seemed from these experiments that this connexion between the swim bladder and the sacculus might increase the acuteness of hearing.

If that were true, we should find a sense of hearing very well developed in all fishes possessing Weberian ossicles. All five species of Cyprinids which have been trained for sounds in our laboratory up to now have a very well-developed sense of hearing. The same is true for *Amiurus*, which belongs to the Silurids. They have Weberian ossicles too. On the other hand, in families having no connexion between the swim bladder and the inner ear, the sense of hearing is very poorly developed. We tried to train for sounds pike, perch, trout, eels and others. Some of them gave no results at all, others could be trained, but the sounds had to be made much louder than for *Amiurus* or for minnows, and the high sounds were never perceived.

Besides Cyprinids and Silurids there are two other families possessing Weberian ossicles: Characinidæ and Gymnotidæ. We trained a *Gymnotus* and some Characinidæ and found a well-developed sense of hearing in all these fish.

Now I wish to direct attention to a peculiar anatomical fact often mentioned in books of comparative anatomy, but never understood. In the Mormyrids, a family of African fish, there is a gas bladder on each side of the skull connected directly with the sacculus. In early embryological stages it is developed as a double cavity of the swim bladder, growing into the head. Later the connexion with the swim bladder is lost by degeneration and the two small air bladders lie completely separated in the skull. I thought that the function of these little air bladders might be the same as that of the big air bladder in minnows and other fishes possessing Weberian ossicles. Sound vibrations reaching the air bladders should cause vibration of them. In this case the stimulus can be transmitted directly to the sacculus, and therefore Weberian ossicles are not necessary. If that is true, we should expect a very well-developed sense of hearing in Mormyrids, although they do not have Weberian ossicles. It was rather difficult to get living Mormyridæ, and we looked for them for several years without success. But finally we got them. We began to train them for sounds with much interest, and we found with satisfaction that they could hear just as well as our best minnows. The anatomical peculiarities of these interesting labyrinths are now being studied in our laboratory.

It may well be asked for what purpose fishes are able to hear so well in silent water. It is not true that all fish are dumb. We know many species of sound-producing fish. There may be many more species of sound-producing fishes not yet known. Some years ago, Dr. Dykgraaf in our laboratory found out that minnows, too, are sound-producing fishes. If they are excited, a soft piping comes from the aquarium. The noise is very soft, but knowing the acuteness of the sense of hearing, we may be sure that it can be heard by the minnows. It is interesting that the production of sound by so well known a fish should have been overlooked for so long. There may be much to discover in the future about the language of fishes.

Organ Pipes and Edge Tones

By Dr. G. Burniston Brown, University College, London

ORGAN pipes have long been a favourite theme for the musician and for the physicist, but they are very far from being the simple structures idealized in the text-books. One source of complication in the actual organ pipe is the behaviour of the air stream at the mouth, which results, for example, in the note produced by blowing in the normal manner being higher in pitch than the natural note of the pipe considered as a resonator.

Another problem connected with the phenomena at the lip is the variation of pitch with the pressure of the air supply: in fact, one of the most puzzling features of the behaviour of organ pipes is the curious succession of tones which is evoked when they are underblown, that is to say, when the air is admitted with slowly increasing pressure. The subject has been investigated by Rayleigh[1], Lutz[2], Gunnaiya and Subrahmaniam[3] and others, and although it had been suggested that the pipe tones were initiated by edge tones, no observations of their relationship were made. A recent investigation has helped to make the production of these tones clearer by showing that they are intimately connected with the general problem of edge tones.

Fig. 1.

STAGES OF VORTEX FORMATION WHEN AIR IMPINGES ON A WEDGE.

An examination of edge tones[4] has shown that, when a jet of air impinges on a wedge, four distinct types or stages of vortex formation may occur. These four stages are illustrated in Fig. 1 for the case where the velocity of the jet is constant and

the heights of the wedge are such that the frequency is the same in each stage. The four stages can also be obtained in succession when the height of the wedge is kept constant and the velocity of the jet is increased: the relation between the frequency n and the mean velocity U in such a case is shown by the thin line in Fig. 2. The frequency rises from A to B (Stage 1), then jumps suddenly to Stage II, continuing to rise until the point D, where another jump to Stage III occurs. The jump to Stage IV is not shown. If the velocity is decreased, the jumps to lower frequencies at C and E do not take place at the same velocity as the jumps to higher frequencies at B and D. When the velocity of the jet is above 500 cm./sec., Stage I may continue and occur simultaneously with each of the other stages.

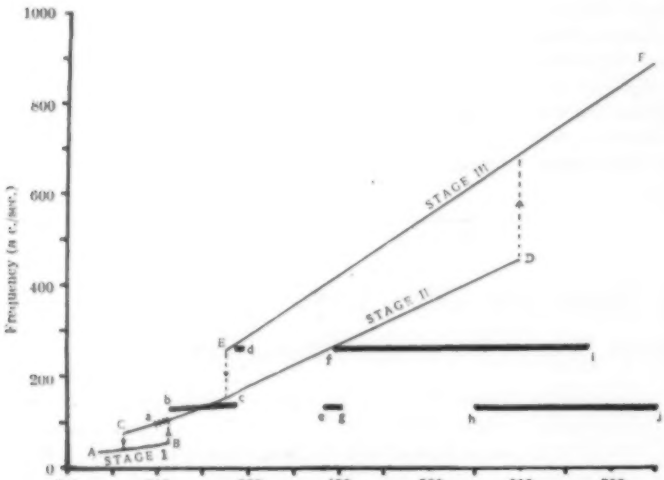

Fig. 2.

OPEN WOOD DIAPASON. FUNDAMENTAL 130 C./SEC.; UNDERBLOWN OCTAVE, 264 C./SEC.

The organ pipe used was an open wood diapason of length 113·5 cm., rectangular in cross-section, 4·7 cm. × 5·8 cm., with a flue of length 4·7 cm. and breadth approximately 0·175 cm. (much nicking), and the cut-up was 1·6 cm., giving a fundamental tone of 130 c./sec. Air impregnated with cigarette smoke was used and the resulting vortex motion examined stroboscopically. The results obtained are shown by the thick lines in Fig. 2.

The free edge tones for a jet of the same width and wedge height as in the pipe were also observed and these produced the thin line *ABCDEF* already described. They are audible when U is above about 500 cm./sec.

The tones emitted by the pipe correspond exactly with those found by Rayleigh. His account of his experiments with an open 2 ft. metal pipe in which the pressure was slowly decreased is reproduced below:

Rayleigh	Diagram
"About this point the octave of the normal note is heard	*i* + *j*
after which the normal note itself disappears	*h*
The normal note reappears, the octave continuing.	*g*
The octave goes	*f*
and then the normal note	*e*
after which there is silence.	*cd*
Octave comes in again,	*d*
and then the normal note, at a pitch which falls from considerably above to a little below the natural pitch.	
At the lowest pressures the normal note is unaccompanied by the octave"	*cb*

In order to explain the mechanism of the production of this sequence, it is more convenient to consider what occurs with increasing velocity. In the pipe used, the construction of the block and lower lip was such that the jet of air is directed outwards and does not encounter the edge until its velocity is 200 cm./sec. Consequently Stage I is unstable and edge tone oscillation commences at *a* (Stage II): when this reaches a frequency of $n = 100$ c./sec., oscillation is set up in the pipe and the edge tone changes suddenly to $n = 126$ c./sec. at *b*, and this frequency is feebly emitted by the pipe. The combination of the pressure changes in the pipe, and those in the wake of the vortices entering the pipe (which according to my theory are the cause of free edge tone production) result in the frequency of pipe and edge tone rising continually and slowly together to $n = 136$ c./sec. at *c*, ($U = 290$ cm./sec.). The pressure changes in the pipe are not sufficient to affect the edge tone any further and the sound ceases. But it happens that Stage III in the free edge tones at $U = 290$ cm./sec. has a frequency very close to the octave, and this gives rise, for a short interval, to a very feeble octave note at *d*.

The construction of the block and lip now causes the jet to pass just *inside* the edge, and silence ensues, together with absence of edge tone oscillation, until the velocity reaches 380 cm./sec. At this velocity a disturbance passing up the jet and striking the edge would produce a frequency of nearly double the fundamental, and pressure variation of this frequency being reinforced by resonance, the note is maintained in spite of the

fact that the jet does not strike the edge centrally. If the velocity is increased very slowly, however, the fundamental is elicited first at *e*. This presumably is due to the fact that the fundamental frequency, $n = 130$ c./sec., is *less* than half the octave, $n = 264$ c./sec., so that the edge tone reaches double the fundamental of the pipe before reaching equality with the octave. When the octave sounds at *f*, the pipe takes complete control and the frequency remains constant (Stage II). When the velocity reaches 550 cm./sec. at *h*, the real fundamental of the pipe begins to sound and the jet oscillates as a whole from side to side (Stage I). The octave note can still be heard but disappears at *i*. The occurrence of Stage I at such a high velocity is quite impossible without a resonator.

It seems, then, that edge tones are responsible for the initiation of the vibrations in musical wind instruments of the organ type, and that even the details of the complex initial phenomena can be accounted for adequately.

[1] Rayleigh, Scientific Papers, **2**, p. 95.
[2] Lutz, P., *Beitrage z. Anat. u. Physiol.*, **17**, 1 (1921).
[3] Gunnaiya, D., and Subrahmaniam, G., *Proc. Phys. Soc.*, **37**, 15 (1924).
[4] Brown, G. Burniston, *Proc. Phys. Soc.*, **49**, 493 and 508 (1937).

Scientific Centenaries in 1938

By Engineer Captain Edgar C. Smith, O.B.E., R.N.

THE scientific centenaries which occur this year are of wide and varied interest. They include the tercentenary of the printing at Amsterdam of Galileo's great work, the "Dialogues of the Two Sciences of Mechanics and Motion", and of the birth of the Scottish mathematician James Gregory; the bicentenary of the death of Boerhaave, the famous Dutch physician and chemist, and the bicentenary of the birth of Sir William Herschel; and the centenaries of the death of Dulong, the French chemist and physicist, and of Nathaniel Bowditch, the American mathematician and astronomer, and also the centenaries of the birth of Sir William Perkin, Ernest Solvay, Cleveland Abbe, George James Symons, Pietro Tacchini and of Count Zeppelin. The year 1738 also saw the publication of Daniel Bernoulli's "Hydrodynamics", while the year 1838 witnessed, first the inauguration of trans-Atlantic steam navigation, and secondly, the opening of the whole of the railway line from London to Birmingham, constructed by Robert Stephenson.

James Gregory (1638–75) was the younger brother of David Gregory (1627–1720). Together they founded the scientific fame of a family of men of science. When about twenty-four years of age, James published his "Optica Promota", containing the description of the Gregorian reflecting telescope, and suggestions for utilizing the transits of the minor planets for accurately determining the solar parallax. He studied at Padua, had a controversy with Huygens, corresponded with Newton, and in 1668 was made professor of mathematics in the University of St. Andrews, and in 1674 professor of mathematics at Edinburgh. In October 1675, while showing the satellites of Jupiter to his students, he was struck blind, and he died a few days later. An English contemporary of Gregory was Edward Bernard (1638–97), who was Wren's successor in the Savilian chair of astronomy at Oxford. He held this post from 1673 until 1691, when he was succeeded by David Gregory, the nephew of James. Bernard was a clergyman, having graduated from St. John's College, Oxford. His sole recorded astronomical observation is that of the solar eclipse of July 2, 1684, but he was an indefatigable collector of mathematical manuscripts. The year 1638 also saw the birth of the French botanist Pierre Magnol (1638–1715) of Montpellier. Both botanist and physician, he held the chair of medicine in his native town and was physician to Louis XIV. In 1705 he visited Paris and was admitted to the Academy of Sciences, but his heart was in his botanic garden at Montpellier. The genus *Magnolia* was named after him by his countryman Plumier.

Among the men of science, besides Boerhaave, who died in 1738, were Benedict de Maillet, the French geologist, and Richard Helsham, the Irish natural philosopher. De Maillet, who was born in 1656, came of a noble family of Lorraine. At thirty-three years of age, he was made consul-general in Egypt, and he held this position for fifteen years. He was also consul-general at Leghorn, and travelled in the Near East. He left a description of Egypt and a geological work in

which he regarded all the rocks of the earth as marine deposits. The work was written in 1715–16, but was not published until some years after his death, when it appeared under the title "Telliamed", an anagram of de Maillet. It contains six imaginary dialogues between an Indian philosopher, Telliamed, and a French missionary. After reviewing this work, von Zittel concluded that "if we except the concluding chapters, the *Telliamed* far outshines other geological writings of the eighteenth century in its wealth of observed facts, its daring originality and its charm of style". Helsham, who was born about 1682, spent nearly the whole of his life in Dublin. A fellow of Trinity College, he lectured on mathematics and was the first to be appointed to the professorship of natural philosophy founded out of the funds left by the merchant Erasmus Smith. Helsham was a great friend of Dean Swift.

Hermann Boerhaave, who was born on December 21, 1668, and died on September 23, 1738, has been referred to as the most celebrated physician of the eighteenth century. He was equally at home in theology, music, botany and chemistry. He extended the botanic garden at Leyden, and in 1718 became professor of chemistry in the University. His well-known work "Elementa Chemiæ" was translated into several European languages. He was a foreign member of both the Paris Academy of Sciences and of the Royal Society. He is buried in St. Peter's, Leyden.

The bicentenary of the birth of Sir William Herschel, who was born on November 15, 1738, will recall the name of one of the greatest of astronomical discoverers. For fifty years his aim was to obtain "a knowledge of the construction of the heavens". In her "History of Astronomy" Miss Clerke wrote: "The rise of Herschel was the one conspicuous anomaly in the astronomical history of the eighteenth century. It proved decisive of the course of events in the nineteenth. It was unexplained by anything that had gone before; yet all that came after hinged upon it. It gave a new direction to effort; it lent a fresh impulse to thought. It opened a channel for the widespread public interest which was gathering towards astronomical subjects to flow in". The year 1738 also saw the birth of the famous French hydrographer, Charles Pierre Claret, Comte de Fleurieu (1738–1810), who had been entrusted with the testing of the marine chronometers of Berthoud, and who organized the expeditions of La Perouse and D'Entrecasteaux; the French aeronaut Jean-Pierre Blanchard (1738–1809), who with Dr. John Jeffries on January 7, 1785, made the first crossing of the Channel by balloon; the German mineralogist Franz Ludwig von Cancrin (1738–1816), who directed the salt mines of Russia and published a work in thirteen volumes on mining; and also of Christophe-Philippe Oberkampf (1738–1815), who added to the wealth of France by introducing the art of calico printing. Born in Germany, his life's work was done in France, and he received a decoration of the Legion of Honour from Napoleon.

Of the men of science who died a century ago, passing mention may be made of Samuel Woodward (1790–1838), the Norwich bank clerk who published a book containing a list of all British fossils then known; Thomas Andrew Knight (1758–1838), the horticulturist whose efforts were directed to the improvement of fruit trees; Charles Tennant (1768–1838), who in 1799 patented a process for the production of bleaching powder, and in 1800 founded the great chemical works at St. Rollox, Glasgow; Bernard Courtois (1777–1838), the discoverer of iodine; and Pierre-Louis Dulong (1785–1838), a professor at the Paris Ecole Polytechnique and one of the secretaries of the Paris Academy of Sciences, who with Alexis-Thérèse Petit (1791–1820) made important investigations in heat and chemistry. Nathaniel Bowditch, who also died in 1838, began life in a ship-chandler's shop, but rose to be president of the American Academy of Arts and Sciences. His great work was his translation, with a commentary, of Laplace's "Mécanique Céleste", which Simon Newcomb said "made an epoch in American science by bringing the great work of Laplace down to the reach of the best American students of his time". His countryman, Colonel John Stevens (1749–1838), a pioneer of steam transport, constructed the first steam boat driven by a screw propeller, and with his sons did much to further both railways and steam navigation.

The work of this last group of men belongs to the early part of the nineteenth century, just when the value of scientific studies was becoming increasingly appreciated, when technical schools were being opened and physical and chemical laboratories were being established. The seed sown in these laboratories was to bear a fruitful harvest, and no industry benefited more from their establishment than the chemical industry. A century ago, Liebig was making the Giessen laboratory the Mecca of chemical students, and Wöhler had already begun teaching at Göttingen. One of Liebig's students was Hofmann, who came to London in 1845 to teach at the old Royal College of Chemistry, in which Sir William Perkin—whose centenary occurs in March—was studying when he made the discovery which laid the foundation of the coal-tar colour industry. Perkin was only eighteen years of age when he discovered aniline

mauve and only nineteen when he started its manufacture at Greenford Green, near Harrow. Fifty years later, he was the central figure of a great international gathering which assembled to celebrate the jubilee of his discovery. The agricultural chemist Robert Warington (1838–1907) also owed something to Hofmann. Warington worked under both Lawes and Frankland, and for many years took part in the work at Rothamsted. Other chemists born a century ago were Wladimir Markownikoff (1838–1904), whose work was of great importance to the Caucasian petroleum industry; Ernest Solvay (1838–1922) whose patent of 1863 led to a revolution in the manufacture of common soda, and François Lecoq de Boisbaudran (1838–1912), who first isolated gallium and received the Davy Medal of the Royal Society.

Passing from the ranks of the chemists to those of the physicists and astronomers, two of the outstanding meteorologists of last century were George James Symons (1838–1900) and Cleveland Abbe (1838–1916). Symons was the founder of the British Rainfall Organisation and of *Symons' Meteorological Magazine*, now the *Meteorological Magazine*. He was twice president of the Royal Meteorological Society, and every two years his name is recalled by the award of the Symons Medal founded to his memory. Abbe at first was an astronomer, but from the passing by the United States Congress of the Weather Bureau Act in 1870 until his death he was the leading meteorologist in his country. Among Abbe's countrymen were James Craig Watson (1838–80), director of the Ann Arbor Observatory, who discovered twenty-two minor planets and wrote a standard text-book on theoretical astronomy, and George William Hill (1838–1914), who in 1909 was awarded the Copley Medal of the Royal Society for his researches on the theory of the moon. Hill's career was bound up with the "American Ephemeris and Nautical Almanac". Two other astronomers born at the same time were Pietro Tacchini (1838–1905), the successor of Secchi at the observatory of the College Romano and the organizer of the Meteorological and Geodynamical Institute of Rome, and Arthur Auwers (1838–1915), whose work was mainly concerned with the fundamental systems of star places and proper motion. His new "Reduction of Bradley's Observations" occupied him from 1866 until 1876. In 1912, the fiftieth anniversary of his doctor's degree, the Berlin Academy of Sciences instituted the Bradley Medal and British astronomers presented Auwers with a copy of the portrait of Bradley by J. Richardson.

To these names may be added those of Ernst Mach (1838–1916) of Prague and Vienna, whose researches in mechanics led him to study by means of photography the motion of a bullet through air; Karl Selim Lemström (1838–1904) of Helsingfors, who made researches on atmospheric electricity, and the effect of electricity on plants; Carl-Louis Schwendler (1838–82), an electrical engineer of German nationality who worked many years with the telegraph department of India; and General Charles Webber (1838–1904), an officer of the Royal Engineers, who was also an expert in telegraphy and assisted the Post Office to organize its telegraph department and with Sir Francis Bolton in 1871 founded the Society of Telegraph Engineers, now the Institution of Electrical Engineers. The geologists, Sir William Boyd Dawkins, Ferdinand Stoliczka and Alfred Elis Törnebohm, were also born in 1838, as was Sir Walter Lawry Buller, the New Zealand ornithologist, to whom there is a tablet in St. Paul's Cathedral.

Of the many inventors and engineers born in 1838 who in one way or another made their mark, Samson Fox (1838–1903) was the inventor of the corrugated flue for boilers which was adopted in all classes of steamships, and a pioneer of the acetylene industry; Peter Brotherhood (1838–1902) was a pioneer in the construction of high-pressure air compressors and of high-speed steam engines; Charles Edward Emery (1838–98) did important work in marine engineering and was responsible for the construction of a central station for house-to-house distribution of steam; Henry Spencer Palmer (1838–1893), a British military engineer, was a geodicist of note and designed the Hong Kong Observatory as well as public works in Japan; William Henry Maw (1838–1924) was president of the Institution of Civil Engineers and of the Royal Astronomical Society and for more than fifty years editor of *Engineering*, while William Cawthorne Unwin (1838–1933) was, in the words of Lord Balfour, "one whose name was honoured wherever engineering was studied in English-speaking lands". Count Zeppelin, who has already been mentioned, was born on July 8, 1838, and died on March 8, 1917, eighteen years after he had built his first airship.

Of all the achievements of engineers in 1838 the place of honour belongs to the men who promoted the plans and built the ships for trans-Atlantic steam navigation. Four steamships, the *Sirius*, *Royal William*, the *Liverpool* and the *Great Western*, made passages between England and New York in 1838, but it was the performances of Brunel's *Great Western*—the *Queen Mary* of her day—that opened men's eyes to the possibilities of steam navigation. The centenary of her first voyage will be commemorated in various ways, and a special exhibition in connexion with the event is being arranged at the Science Museum, South Kensington.

Obituary Notices

Dr. G. A. Boulenger, F.R.S.

GEORGE ALBERT BOULENGER, who died on November 23 at St. Malo at the age of seventy-nine years, was one of the most distinguished of a line of descriptive biologists who have brought fame to the British Museum during the past century.

Born at Brussels on October 19, 1858, the son of Gustave Boulenger, a notary of Mons, Boulenger early exhibited a passion for natural history, and particularly for reptiles and batrachians. While still studying at the University of his native city, he was already engaged in the determination of reptiles, batrachians and fishes in the Natural History Museum at Brussels, and in 1880 he was appointed assistant naturalist in that institution. This appointment he very soon resigned, and came to London at the invitation of Dr. Günther, then keeper of zoology in the British Museum, in order to prepare a new catalogue of the batrachians in the national collection. In the words of Günther, "this proved to be the beginning of a long, most meritorious and beneficial service".

In 1882 Boulenger was appointed a first-class assistant in the Department of Zoology, a position which he held until his retirement in 1920. One of his first duties was the supervision of the removal of the spirit collections from Bloomsbury to South Kensington.

Gifted with tremendous energy, an extremely methodical mind, and a memory that was little short of amazing, Boulenger accomplished a vast amount of scientific work during his forty years at the museum. From 1882 until 1920 a continuous stream of papers flowed from his pen. A list of his herpetological and ichthyological contributions published by the Zoological Society of Belgium in 1921 includes no less than 875 papers in scientific journals and other periodicals, and takes no account of numerous articles of a more popular nature in the *Field*, *Country Life*, etc. His most important contributions to science, however, were the elaborate and detailed monographs, mostly published by the British Museum, which remain to this day the solid foundation of all modern systematic work on the groups of animals concerned. Of these, mention may be made of the "Catalogue of Batrachians . . ." (2 vols., 1882), "Catalogue of Lizards . . ." (3 vols., 1885–87), "Catalogue of the Chelonians, Rhynchocephalians, and Crocodiles . . ." (1889), "Catalogue of the Snakes . . ." (3 vols., 1893–96), "Monograph of the Lacertidæ" (1920), all published by the Museum; the volume on reptiles and batrachians in the Fauna of British India series (1890); and the monograph on the tailless batrachians of Europe, published by the Ray Society (1897–98). The first (and only) volume of a new edition of the "Catalogue of Fishes . . ." (1895), covering several important Percoid families; "Les Poissons du Bassin du Congo" (1901); "Fishes of the Nile" (2 vols., 1907); the systematic section on the Teleostei in the "Cambridge Natural History" (1910); and "Catalogue of the Fresh-water Fishes of Africa . . ." (4 vols., 1909–15); are perhaps the most valuable of his major contributions to systematic ichthyology, and are veritable monuments of painstaking research. The Museum "catalogues" are worthy of special mention, since they represent complete revisions of large groups of animals from all over the world, and, for the most part, they are to-day still the only complete revisions of the groups concerned. That, in addition to this prodigious output of scientific work, Boulenger was able to find time to prepare the sections dealing with reptiles, batrachians and fishes in the *Zoological Record* every year from 1880 to 1904, is a tribute to his amazing and indefatigable energy.

Boulenger's study of the rich collections of fresh-water fishes obtained in the Congo basin about 1898, and of those collected during the Egyptian Government's survey of the Nile, directed his special attention to the fishes of the African continent, and these remained his principal interest during the remainder of his museum career. Determined to use every effort to fill the gaps in the national collection, he encouraged travellers and residents in various parts of Africa to send home specimens, with the result that the British Museum now possesses a collection of African freshwater fishes unparalleled in the world. His intensive study of these fishes led him to formulate certain general conclusions concerning the origin and distribution of the African fish-fauna, and his views were ably summarized in his presidential address to Section D (Zoology) of the British Association in 1905. The study of this illuminating address may be recommended to those of the younger school of zoologists to whom systematic zoology is a convenient method of cataloguing, and something quite apart from modern conceptions of science.

On his retirement in 1920, herpetology and ichthyology were almost entirely abandoned in favour of another abiding interest. Long attached to the study of flowers, and particularly of roses, he had spent many of his vacations during his later years at the Museum in visiting various European countries in search of data and specimens. He now became attached to the Botanical Gardens in Brussels, where he undertook the study of the fine series of roses in the herbarium of François Crépin. He was engaged upon a monograph of the European roses at the time of his death, and two volumes had already been published under the title of "Les Roses d'Europe de l'Herbier Crépin".

Boulenger's work was widely recognized by corresponding or honorary membership of many learned societies both at home and abroad. He was elected a fellow of the Royal Society in 1894, and served on the Council. He was also a member of the Council of

the Zoological Society nearly continuously from 1893 until 1911, and was for several years a vice-president. He was a doctor *honoris causa* of Louvain, Giessen and St. Andrews, and received a silver medal from the Société d'Acclimatation de France. In 1935, the American Society of Ichthyologists and Herpetologists elected him as its first honorary member, and in 1937 the country of his birth conferred upon him the Order of Leopold, an honour which gave him great pleasure and of which he was justly proud.

The writer of this notice did not come into contact with Boulenger until shortly after his retirement, but he cherishes the memory of several informal talks and discussions. The kindness and courtesy shown to a beginner by one who was the acknowledged master of his subject will always be remembered, and played no small part in the writer's education in systematic ichthyology.

A naturalized Englishman, Boulenger married Emilie, daughter of Charles Heyman of Brussels, who died in 1936. He leaves three sons, two of whom have adopted zoology as a profession. J. R. N.

Prof. A. J. Ewart, F.R.S.

ALFRED JAMES EWART, who died suddenly at his home near Melbourne on September 12, was the first professor of botany to be appointed in any Australasian university. Born at Liverpool on February 12, 1872, he was educated at Liverpool Institute and the University of Liverpool. He afterwards worked in the Universities of Leipzig (Ph.D.) and Oxford (D.Sc.). After a period as science master at the King Edward School, Bromsgrove, he became lecturer in botany at the Municipal Technical School and deputy professor in the University at Birmingham.

In 1906 the Government of Victoria decided that a successor must be appointed to Baron Sir Ferdinand von Mueller as Government botanist, and that the duties could be combined with those of a chair of botany at the University. For fifteen years, Ewart carried the heavy double burden, spending half his day at the University and half in the Herbarium at the Botanic Gardens, South Yarra, two or three miles away across the city. Ewart was further handicapped by lack of laboratories. Botany in the University had been split from the Department of Biology, and still shared the same building. It was not until 1929 that the Department was able to remove to buildings of its own. Ewart was justly proud of the fine Institute which was officially opened in November of that year. He had been elected a fellow of the Royal Society in 1922.

Ewart is best known to British botanists as a plant physiologist, the translator of Pfeffer's "Plant Physiology" and the author of a monograph on protoplasmic streaming published by the Oxford University Press. At about the time of his appointment to Melbourne he was engaged in work upon the ascent of water in trees (*Phil. Trans.*, 1905 and 1908), but after his arrival in Australia systematic and economic botany occupied most of his time. This did not prevent his publishing upon such a wide range of subjects as the longevity of seeds, photosynthesis, the chemistry of chlorophyll and the sensitivity of apples to poisons. This last work led him to hold certain views as to the cause of bitter pit in apples by metallic poisoning. His contributions to the flora of Australia number thirty-six papers. He also published a "Flora of the Northern Territory" in 1918 and in 1930 there appeared his "Flora of Victoria", a book of some 1,000 pages with 400 line drawings. This work is of great value to students in that State. Until its appearance, there was only an incomplete flora by von Mueller and the "Flora Australiensis" for reference.

Ewart's duties as a Government botanist compelled him to pay much attention to weeds and poisonous plants. His services were utilized by the Federal Government in connexion with stock poisoning along the overland route from the Northern Territory to Oodnadatta. In the winter of 1924 he visited Central Australia to examine the problem in the field.

Ewart was a man of robust physique. He delighted in country life and hard physical work. He found much pleasure in the labour of clearing and burning bush around his country cottage near Healsville, close to the heart of the giant eucalyptus forests. He was, however, keenly interested in forestry education and in efforts to develop a forest consciousness in Australia. In 1925 he published a "Handbook of Forest Trees" for use in Victoria, and at the time of his death he was chairman of the Forestry Examinations Board.

For the last two years of his life, Ewart had been far from well. He developed heart trouble. His sudden death, at the comparatively early age of sixty-five years, is a severe loss to his friends and colleagues.

T. G. B. O.

WE regret to record the death of Miss Lilias Armstrong (Mrs. S. Boyanus), which took place unexpectedly in London on December 9. Miss Armstrong was one of the foremost exponents of the science of phonetics, and was well known for her studies of the phonetic systems of the African languages. Lilias Armstrong, the daughter of the Rev. J. W. Armstrong, was a graduate of the University of Leeds. She joined the staff of the Department of Phonetics of University College, London, in 1918. Her abilities as research worker, teacher and organizer won her a world-wide reputation, which was recognized when at the close of the academic year 1936–37 the University of London conferred on her the title of reader. Miss Armstrong was the author of a large number of books dealing with the phonetics of English, French, Burmese, Somali and Kikuyu. It is especially in connexion with the two last named that Miss Armstrong's contributions to the study of languages were of especial note. Her phonetic studies put the grammar of these two languages on a new basis, her most remarkable discovery being the function in them of voice pitch, by which in both, she discovered, grammar and meaning are determined.

News and Views

British Association: Sectional Presidents

THE annual meeting of the British Association will be held in Cambridge on August 17–24, 1938, under the presidency of the Right Hon. Lord Rayleigh. The following sectional presidents have been appointed: Section A (Mathematical and Physical Sciences), Dr. C. G. Darwin; B (Chemistry), Prof. C. S. Gibson; C (Geology), Prof. H. H. Swinnerton; D (Zoology), Dr. S. W. Kemp; E (Geography), Prof. T. Griffith Taylor; F (Economics), Mr. R. F. Harrod; G (Engineering), Prof. R. V. Southwell; H (Anthropology), Prof. V. Gordon Childe; J (Psychology), Dr. R. H. Thouless; K (Botany), Prof. W. Stiles; L (Education), Mr. John Sargent; M (Agriculture), Prof. R. G. Stapledon.

Mr. R. A. Smith

MR. REGINALD ALLENDER SMITH, who retires from the office of keeper of the Department of British and Medieval Antiquities of the British Museum (Bloomsbury) on January 4, has held that appointment since 1928. Mr. Smith had had a long period of previous service in the Department as assistant keeper, entering it when, under the late Mr. (afterwards Sir) Charles Hercules Read, it still included the exhibits in ethnography. Although the whole field of British prehistoric archæology lies within the range of Mr. Smith's expert knowledge, it is more particularly on the palæolithic period and the Iron Age that he is regarded as of the highest authority, and that on certain classes of disputed questions his judgment has been in a sense a court of final appeal. Of the official guides and other publications of the British Museum, of which Mr. Smith is sole or part author, the catalogue of the Sturge collection of stone implements is perhaps of the most enduring value to the student. Mr. Smith is not only the author of a large number of the archæological chapters in the various volumes of the "Victorian History of the Counties of England", but he has also made numerous valuable and authoritative contributions to the literature of archæology in the pages of learned and scientific publications dealing with the subject, more especially those published by the Society of Antiquaries of London, of which society he has acted as secretary and for some years past has been the director.

Mr. T. D. Kendrick

MR. THOMAS DOWNING KENDRICK, who will succeed Mr. R. A. Smith as keeper of the Department of British and Medieval Antiquities of the British Museum, has been an assistant keeper in that department for some years. Since the publication of his first book "The Axe Age", Mr. Kendrick has been recognized as an archæologist whose views are original, but at the same time carefully observant of the limitations of the evidence. Of recent years Mr. Kendrick has made a special study of the form and technique of the Celtic or British decorative art of the Iron Age and the British and Scandinavian art forms of the early historic period, on which he has contributed a number of papers to archæological publications. Among his more important published works are "The Archæology of the Channel Islands", of which one volume only has as yet appeared, "The Druids", "A History of the Vikings" and "Archæology of England and Wales, 1914–1931", the last-named in collaboration with Mr. C. F. C. Hawkes. He is also the editor of that valuable and scholarly series, "The County Archæologies".

Lord Nuffield's New Gift to Oxford

THE endowment of demonstratorships and assistantships in the Oxford Medical School, to be held by graduates from Australia, New Zealand and South Africa, will now be possible thanks to Lord Nuffield's latest gift to the School of £168,000. It is intended with this money to establish three demonstratorships in the pre-clinical departments of anatomy, biochemistry, pathology, pharmacology, and physiology, and three assistantships in the departments of medicine, surgery, obstetrics and gynæcology, anæsthetics, orthopædic surgery, and therapeutics. These posts will be held for a fixed period by graduates eligible for, or already holding, research posts in the universities of Australia, New Zealand and South Africa which grant medical degrees. The holders will be selected in rotation by these universities and appointed to the particular department in Oxford which is theirs. They will thus enjoy all the advantages of membership for a time of the Oxford Medical School. Oxford will benefit by the presence of these additional highly qualified workers; and the Dominions concerned will benefit by their experience on their return.

The Royal Botanic Garden, Calcutta

THE Royal Botanic Garden, Calcutta, is celebrating the completion of its 150th year on January 6, during the jubilee meeting of the Indian Science Congress, and a number of distinguished botanists from Great Britain expect to attend. The Garden was started at the suggestion of Lieut.-Colonel Robert Kyd, and continued as the Honourable East India Company's Botanic Garden until the Company relinquished its control of the government of India in 1857, when it became the Royal Botanic Garden, Calcutta. Colonel Kyd was appointed superintendent of the Garden and continued in that position until his death in 1793. Then it was decided

to appoint a special officer, and the East India Company's botanist, Dr. William Roxburgh, held the post from 1793 until 1813. Roxburgh published his "Flora Indica", which became the basis of many subsequent Indian botanical works. In spite of a series of well-known superintendents (F. Buchanan (afterwards Hamilton), N. Wallich, W. Griffith, Hugh Falconer, T. Thomson, T. Anderson, C. B. Clarke, G. King), the Garden suffered vicissitudes of progress and serious set-backs. Cyclones practically devastated the grounds on more than one occasion, and once the Herbarium became seriously depleted through supplying other herbaria too lavishly. Recovery began under the administration of Dr. (afterwards Sir) George King, who retired in 1897; and still further improvements were made under Sir David Prain, who succeeded King and remained superintendent until 1905. Since that date, the Garden has continued performing important functions under the administration of several successive superintendents. The present superintendent is Mr. K. P. Biswas, who, until his recent promotion, was curator of the Garden Herbarium. For several months since relinquishing his curatorship, Mr. Biswas has been working at the Royal Botanic Gardens, Kew. The Garden lies on the right bank of the River Hooghly, at Sibpur, just outside Calcutta; and is now about 270 acres in extent. Apart from work of a 'pure' botanical nature, much work of economic importance —chiefly to India—is being pursued along lines similar to those obtaining at Kew. The authorities are to be congratulated on the Garden attaining its 150th anniversary, and Mr. Biswas on his recent appointment as superintendent.

An Early Text-book of Chemistry

THE small text-book on chemistry, "Tyrocinium Chymicum", of Jean Beguin, a native of Lorraine, was first published anonymously in 1610 and went through a large number of editions. The first issue was intended for the use of Beguin's own pupils in a school of pharmacy he established in Paris, but it was pirated and re-issued in Cologne in 1611. Beguin then re-issued it in 1612. Prof. T. S. Patterson, in a paper on "Jean Beguin and his *Tyrocinium Chymicum*", published in *Annals of Science* (**2**, 243–298; **1937**), has given a very full account of the various editions of the book and a description of its contents. As he says, "it is certain, on account of the large number of editions issued, that Beguin's little book was found to be of great practical value, and it must have done much in unostentatious fashion to guide real chemistry along a sound experimental path. . . . Beguin was much under alchymical influence . . . but his was a commonsense alchymy and he used its philosophy in an entirely reasonable manner. There was little of the fantastic and nothing of the quack or impostor, or even of the willing dupe or self-deceiver, in him." In a preface by Barth in a later edition, it is said: "Beguin, on account of his virtue, opened his school in Paris—that celebrated emporium of all the wits, and compendium of the whole world—and did not burden his pupils and learners (for princes, counts, nobles, councillors and doctors, attracted by its novelty, meanwhile frequented his chemical laboratory) with useless and prolix comments and various descriptions of his remedies, but prepared in their sight candidly and simply, the secret medicaments of Quercetanus and others, of all kinds both solution and coagulation".

Science and Mankind

THE *Manufacturing Chemist* of November includes a further symposium of notes from contemporary scientific workers on "Science and Mankind". Contributions in the October number from Mr. H. G. Wells, Sir Richard Gregory, Prof. L. Hogben, Prof. H. Levy and Sir Daniel Hall are followed by others from Prof. J. B. S. Haldane, who stresses the importance of adequate organization to supply the Press with scientific news, and of thinking rationally about economics and politics, and Mr. C. S. Garland, who directs attention to the vital need for an organization which can speak for science as a whole and of the importance of having representatives in Parliament who are really concerned with the welfare of the profession as a whole. Sir Ernest Graham-Little outlines the contribution which medical science can make to improve social conditions. Dr. W. Cullen, while pointing out that the ultimate effects of a scientific or technical discovery are largely unpredictable, stresses the impossibility of stopping scientific and technical progress and, while condemning the prostitution of science as in warfare, directs attention to the way in which social conditions have been improved by scientific and technical advances. Prof. Alfred Stock expresses the hope that the progress of chemistry and physics has rendered war so terrible that the use of brute force will be renounced by the nations in reality, and that then science will be able to devote itself completely to the welfare, health and enjoyment of existence of mankind.

Research in Canada

THE nineteenth annual report of the National Research Council of the Dominion of Canada, for the year 1935–36, refers to the valuable work of the Division of Chemistry on the utilization of Alberta's natural gas. Optimum conditions have been determined for the production of ethylene, and a method has also been developed giving three to four gallons of benzene from each thousand cubic feet of Turner Valley stabilizer gas. Reference is also made to the synthesis of a number of plant hormones and to the discovery that alkaloids of the giant larkspur, a plant growing wild in southern Alberta, are powerful insecticides. The Division of Chemistry has also developed an improved method of measuring the hiding power of paints, and the wax mixture previously developed for use in plucking chickens has now come into wide use in preparing poultry for the market. Dry-cleaning research has included the study of non-inflammable cleaning solvents, such as trichloroethylene, the manufacture of which is being undertaken in Canada. The Division of Biology and Agriculture has compiled an extensive review of the

literature on weed killers as a guide to experimental work in this field. The extent of insecticide taint in wheat, the requirements of barley suitable for malting, especially for the British market, cold storage of fowls, fruit and other food products have all received attention, and physical conditions necessary for dechilling boxed poultry have been established which prevent the formation of condensate, a blemish which lowers the market quality.

THE Division of Physics and Engineering has been responsible for a good deal of standardization work in co-operation with the National Bureau of Standards, Washington. A 'reverberation chamber' has been built and used for measurements of the sound-absorbing properties of various kinds, building materials for Government departments and commercial firms. Apparatus completed during the year has enabled the Division to make thermal insulation tests on large samples of insulating materials, partitions and wall sections. An experimental investigation of the heating of railway refrigerator cars in winter has been completed, and in addition to aerial surveys the Division has been concerned with a number of aviation problems, including the development of a new type of aircraft ski. The Division of Research Information is being vigorously developed and the report also refers to conferences on forestry and fish culture and to the work of a number of associate committees, as well as to the assisted researches, for which grants amounting to 158,968 dollars were provided during the year, and to the 685 scholarships awarded to 385 persons, representing total grants of 570,053 dollars.

Cancer Research in Australia

THE report of the eighth Australian Cancer Conference, which was held in Canberra in April last, shows that it was a meeting well attended by representatives from Australasia. The recommendations of the Conference of the previous year appear to have been largely acceptable to the Commonwealth Government for, on September 24, 1936, a National Health and Medical Research Council was instituted by an Order in Council. The recommendation that the Commonwealth Government should appoint an Australian Cancer Commission did not, however, prove acceptable. Among other resolutions of the present year's Conference may be mentioned a recommendation that the Commonwealth Government should make available the sum of £30,000 annually for the purpose of establishing a permanent and reliable system of medical research. There is little doubt that a most lively interest is being taken officially by Australia in the subject of cancer among its population. This is reflected not only in public action but also in the publications which appear from time to time dealing with various aspects of this subject. "Physical Aspects of Radium and Radon Therapy" is a booklet prepared by Dr. C. E. Eddy, physicist-in-charge of the Commonwealth X-ray and Radium Laboratory of the University of Melbourne, and Mr. T. H. Oddie, more especially for the use of radiotherapists and officers of local physical services. The booklet of sixty pages gives an extremely good account of the general physics of the substances and radiations used in radiotherapy together with an account of precautions necessary in using them. The relative advantages and disadvantages of radium and radon are also dealt with in a thoroughly explicit manner.

Edible Birds Nests in the Philippines

The edible nests of swiftlets, valued as a delicacy and as food for convalescents by the people of China, are built in limestone caves along the seashore in many parts of the Philippines. The export of the nests is in the hands of local Chinese merchants, and although accurate statistics are difficult to obtain it has been stated that the Netherlands Indies in 1927 exported 109,310 kilograms of nests valued at 822,913 guilders. In only one of the Philippine Islands, Bacuit, has an attempt been made to derive municipal revenue from the trade, when in 1927 the traditional ownership of the birds nest caves, which had existed for generations, was supplanted by municipal ownership and the annual leasing of the caves to the highest bidder. As a reply to this move, the Chinese dealers formed a ring so that the bidding, which reached 1,700 pesos in 1927, had fallen in 1936 to 500 pesos, and in a footnote to a recent paper on the subject, Canuto G. Manuel states that as no bid at all was offered in 1937, the caves have relapsed to the system of traditional ownership (*Philippine J. Sci.*, 62, 379, March 1937). From Bacuit, approximately 500 kilograms or about 100,000 nests are exported annually, but poaching of nests is common, and attempts to limit the collecting with the view of conserving the stock have met with little success. Nest collecting, however, is a dangerous occupation, and the fact that some inaccessible caves are tenanted by the birds, which belong to the racial form, *Collocalia francica germani*, provides for the survival of the swiftlet.

Literature of Food Investigation

IN its report for 1936, the Food Investigation Board stated that a committee had been appointed to review both the scope and the form of its publication, "The Index to the Literature of Food Investigation". The first number of this journal appeared in 1929 and at present it covers about a hundred scientific and technical periodicals, each number containing upwards of 2,000 references, in the form of elaborated titles that indicate the scope of the papers indexed, but omit all experimental data. The original intention was that the "Index" should deal solely with the transport and storage of foodstuffs; it now tends to cover, however, the wider diverse field that lies between agriculture, or production, and nutrition, or the use of food for the maintenance of health. The first number of volume 7, which covers the literature published in 1934, has been issued ("Index to the

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NATURE

SUPPLEMENT

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Science and the Unobservable*

By Prof. Herbert Dingle, Imperial College of Science and Technology

A NEW phenomenon has appeared in modern physics, namely, an attempt to apply with rigour the principle that only that which is observable is significant. This is not intended to be a precise statement of the principle. It is at least vague, and perhaps inaccurate, but on that very account it is the most suitable statement with which to begin our discussion. For the principle itself has not yet been clearly isolated from its applications. Consequently it is manifested here in one form and there in another, appearing to some as an outstanding example of scientific arrogance and even absurdity, while to others it has an authority which raises it above common sense and reason alike. It is therefore important to try to understand the meaning of the principle and to reach a point of view from which its validity may be justly appraised.

It is Einstein who is responsible for the present virility of the principle. Let us hear him speaking of the crux of his theory—the idea of the simultaneity of events occurring at different places.

"The concept" of simultaneity, he says, "does not exist for the physicist until he has the possibility of discovering whether or not it is fulfilled in an actual case. . . . As long as this requirement is not satisfied, I allow myself to be deceived as a physicist (and of course the same applies if I am not a physicist), when I imagine that I am able to attach a meaning to the statement of simultaneity. (I would ask the reader not to proceed farther until he is fully convinced on this point.)"[1]

Here, on the other hand, is a comment by M. Jacques Maritain, the well-known French Catholic philosopher, on this passage:

"Let us, then, obey our author and read no farther, for this little parenthesis, 'the same applies if I am not a physicist', is of direct concern to us who have not the honour to be physicists, and it presumes to introduce us into the most fallacious metaphysics. . . . It is a fault so obvious to the eyes of a philosopher to confuse the *meaning* of a concept . . . with the *use* which may be made of the concept in this or that field of study, . . . that we hesitate to impute such a mistake to anyone, whoever he may be. Everything goes to show, however, that Einstein has made this mistake."[2]

It is not surprising that a physicist and a philosopher should take opposite views of this question, but the matter cannot be disposed of on simple psychological grounds. Here are the diametrically opposed views of two men of science:

"The general point of view" of relativity, writes Prof. C. G. Darwin, "of questioning the reality of anything unobservable is one of the greatest revolutions in scientific thought that has ever occurred. . . . The great idea which Einstein contributed to scientific philosophy was the principle that if a thing is essentially unobservable then it is not a real thing and our theories must not include it."[3]

This remark has caught the eye of Mr. Albert Eagle, now a mathematician, but in other days an experimental physicist, whose name is known wherever spectroscopy is practised.

"To me," says Mr. Eagle, "this 'great idea' is the most savage example of the application of

* From a Friday evening discourse delivered at the Royal Institution on November 26.

what is known as the principle of *Occam's Razor* of which I have heard. . . . Einstein's 'great idea' requires us to surrender our common sense for the sake of an arbitrary dictum of his which he and his followers have raised to a fetish. It is preposterous, and to my way of thinking is so inherently idiotic that I cannot understand anyone wasting his breath in giving utterance to such a view."[4]

Finally, here is the attitude of another philosopher, Rudolf Carnap—perhaps the leading exponent of the most active of modern schools of philosophy, the so-called "logical positivism". Carnap, the philosopher, not only accepts the principle; he uses it to reduce to nonsense those branches of his own subject known as metaphysics and ethics.

"I will call *metaphysical*", he writes, "all those propositions which claim to present knowledge about something which is over and above all experience. . . . Metaphysicians . . . are compelled to cut all connection between their propositions and experience; and precisely by this procedure they deprive them of any sense."[5]

Now when men who are neither fools nor liars agree that a certain idea is either the greatest discovery of a generation or the silliest nonsense imaginable, but cannot agree as to which it is, it is clear that there is more than a difference of opinion; there must be some defect of understanding also. It therefore becomes a matter of importance to state this principle precisely, so that we shall at least know what we are doing when we bless or curse it. And in seeking to assess its value we must avoid the error of ascribing greater or less weight to the opinion of a physicist than to that of another. Einstein is perfectly right in saying that if this principle holds for him as a physicist, it holds for him also if he is not a physicist; and M. Maritain offers him a licence which he cannot accept when he allows him to apply the principle in physics but not outside. If we talk nonsense, and plead in extenuation that we are only talking as physicists, we fall short of the ideal of rational speech, distinguished precedent notwithstanding. The question must be considered on general rational grounds. Are we to admit the unobservable into our scheme of things, or are we not?

Let me for a moment adopt the legal method, and state the case for each side independently, as an advocate might state it. Take first the case for the principle. It is necessary, say its supporters, as a safeguard against irresponsible invention. If we allow that an entity might exist and be significant to thought, although it is essentially unobservable, what is there to prevent us from postulating any number of such entities and invoking them to remove any difficulty that might arise? Suppose, for example, I assert that there is a binkum sitting on the table in front of me, and that this tremendous fact, rightly understood, is the final, completely satisfying solution of the problem of evil. If you reject the principle in question, you have no grounds for denying the statement. You may say that you cannot detect my binkum, but I reply that of course you cannot, because he is unobservable. If you want to know how his existence solves the problem of evil, I say that it is its nature to do so, and the definition of him, according to your own contention, is quite independent of any means you adopt to investigate him. If you ask, "What is a binkum, anyway?" I reply that that is immediately evident; I cannot put it into words, but everyone knows what a binkum is. If you retort that you do not know, I shrug my shoulders and say that you must be speaking as a physicist.

Stupid as this example sounds, it contains a precise parallel to the case of simultaneity. M. Maritain and those who agree with him claim that the simultaneity of spatially separated events is something independent of our means of observing it. When asked what it is, they claim that its nature is immediately evident and that everyone knows it. But Einstein says he does not know it, and Einstein is an honourable man. And the only reply is that Einstein and his followers must be speaking as physicists.

We can now press home the point. We agree, let me assume, that science and philosophy are better without the binkum: How, then, can we exclude him? Only, says counsel for the defence of the principle, by refusing to grant existence to anything that is essentially unobservable, and denying any unobservable property to an existent thing. That means that everything whose existence we acknowledge must be definable ultimately in terms of observation. If there is the slightest relaxation of this requirement, in comes the binkum with passport signed and sealed.

The case seems established, but we must hear counsel for the other side. His argument is a *reductio ad absurdum*. Certainly we do not want the binkum, he says, but your device for keeping him out is both presumptuous and absurd; you are throwing out the baby with the bath-water.

Consider for a moment what your principle implies. It asserts that there is nothing in the universe except what you can observe—nothing in the physical world beyond the reach of your senses. How do you know that the universe does not contain things apprehensible only by senses which you do not possess, which perhaps you have lost in the course of evolution or have not yet acquired? Moreover, what about the past? You cannot observe that, for it has gone; therefore, you say, it has no meaning, it must not come into our description of reality. Such nonsense necessarily follows if your principle is granted. Exclude your binkum by all means—we hold no brief for him; but find some sensible way of doing it, without assuming potential omniscience.

The problem, I think, is now set clearly before us. If we admit the unobservable, there is no check on empty speculation; if we reject the unobservable, we confine the universe within the bounds of human potentialities and make nonsense of history. What are we to do?

It is evident that we must begin by examining the word 'unobservable'. Both sides wish to exclude the binkum; both wish to allow the universe a richer content than we can at present perceive. The 'unobservable' that is to be proscribed must therefore include the obviously idle fancies but exclude the legitimately transcendental.

There are reasons of various kinds why we may be prevented from observing a thing, but I think they can all be summarized under four headings. First of all, there is what I will call the *practically* unobservable; namely, that which is unobservable because of the practical difficulties of observing it. The far side of the moon affords an example. That region is unobservable because we have not solved the problem of interplanetary travel, or performed some equivalent feat of practical ingenuity. It is conceivable that in time this disability will be removed, so that practical unobservability may be merely a temporary characteristic.

Secondly, there is the *humanly* unobservable; by which I mean the unobservable which is so because we do not possess the necessary faculties for observing it. I cannot, of course, by the nature of the case, give examples of this, but I can give analogies. A great deal of the universe would be humanly unobservable if we had no sense of sight; and to the musically insensitive the significance of a great composer may be said to be humanly unobservable. If, then, there is in the universe some existence which no creature has the faculty of apprehending, that existence is humanly unobservable.

Thirdly, there is what I will call the *physically* unobservable. A thing may be said to be physically unobservable when we have the faculty for observing it if Nature will co-operate, but Nature gives that faculty no opportunity for exercise. Thus, if somewhere in space there occurred an event from which no signal—light ray or sound wave or anything else—proceeded to other places, and if there were repulsive forces which prevented us from ever reaching the place of occurrence, that event would be physically unobservable.

Lastly, there is the *logically* unobservable; namely, those things which we cannot claim to have observed without breaking the laws of reason. I doubt if this class is actual, since logic and observation are essentially independent, but it must be included because a great deal has been written about it. An example might be the observation of an object both larger and smaller than a given object; but I give this example with some hesitation because geometers have an uncanny knack of inventing spaces in which such relations might not be incompatible. Be that as it may, however, if we grant a certain minimum of common agreement—such as the acceptance of Euclidean geometry in the present instance—logical unobservability becomes an intelligible notion, and we will accept it as a candidate for inclusion in our principle.

Now this classification may be simplified; for, whatever may be the ultimate truth of the matter, it is not necessary for our purpose to put the humanly and the physically unobservable in separate classes. I will therefore group them together and call them jointly the physically unobservable. The justification for this is that we cannot tell, in any given case, with which class we are dealing. If, for example, a certain substance appears tasteless to everyone (that is, its taste is unobservable), it is impossible to say whether that is because it has a taste which our senses are not keen enough to detect, or because it has no taste to be detected. But now our principle is essentially one which, if valid, must be used; it is not a creed which we are merely called upon to state and may then ignore. The humanly and the physically unobservable, then, become one class so far as our problem is concerned, for if in practice we reject one, we automatically reject the other also.

We have, then, three classes of unobservables, and I think the distinction between them may be expressed most simply in the following way. Let us suppose that we have discovered all the means of observation that exist in the universe, and know all their properties completely. We might then be able to imagine other means of observation which do not exist. Anything which would be observable by such imaginary means, but not by the existing means, would be *physically* unobservable. Anything which would be unobservable by *any* means, existing or imaginable, would be *logically* unobservable. Anything which would be observable by the existing means if we were also omnipotent, but which actually is unobservable because we cannot make full use of the means of observation which exist, would be *practically* unobservable.

We can now proceed a stage further. We have just seen that, for our purpose, the humanly and the physically unobservable become one class because we cannot at present distinguish between them. Let us look, then, at our latest classification, to make sure that the three types of unobservability we have now reached are immediately distinguishable. It is fairly evident, I think, that they are, if we grant the initial supposition that we have discovered all existing means of observation. For brevity, I will call that the assumption of *omniscience*, and you will understand that by this word I do not mean knowledge of everything that exists or that can be observed, but complete knowledge of the existence and properties of every means by which observation is possible. For example, omniscience implies complete knowledge of all the properties of light, but not necessarily of all objects which are visible. Now, clearly, this assumption of omniscience is open to challenge, and it is therefore necessary to see how our classification looks if it is removed. Can we then still recognize the three classes as distinct?

There is no difficulty, I think, with the logically unobservable. Since this class consists of things which are not even *imaginably* observable, it makes no difference how much we know of *possible* observability. There can be no possible means of observation that is not imaginable. The logically unobservable, then, forms a definitely distinguishable class, independently of our assumption of omniscience.

The case is different, however, with the practically and the physically unobservable, for these classes *cannot* be distinguished if we do not regard ourselves as omniscient. We said that the far side of the moon was practically unobservable, but if we are not omniscient, how do we know that when we have overcome what seem to be the present obstacles, Nature will not face us with some unexpected difficulty like that which she kept in store for our efforts to determine our motion through the ether? If she does, and persists in doing the same kind of thing, we shall have to call the far side of the moon physically and not only practically unobservable. And, on the other hand, when we say that absolute motion is physically unobservable, we are again assuming omniscience. We cannot observe such motion by optical, acoustical, electro-magnetic or any other means within our present knowledge, but, without the assumption, who can say that there is not some undiscovered physical medium through which it may be detected? If there is, absolute motion is merely practically, and not physically, unobservable. It is clear, I think, that unless we are omniscient the two classes are indistinguishable.

Our analysis of unobservability, then, finally brings us to this. If we assume that we are omniscient we can distinguish three classes—the *practically*, the *physically* and the *logically* unobservable. If we do not assume that we are omniscient we can distinguish only two classes—the *actually* and the *logically* unobservable, let us call them. The importance of this conclusion for our purpose is this. We are going to look at the actual practice of physics, to see what kinds of unobservable are excluded and what kinds are not. If we find that a distinction is made between the practically and the physically unobservable, then we know that physics is assuming omniscience; but if no distinction is made, then there is no such assumption.

Let me state the result at once, afterwards giving examples to justify the statement before proceeding to consider the validity of the principle we are considering in its definite form. The practice of physics is to recognize three classes—the practically, the physically and the logically unobservable. Of these it excludes the physically and the logically unobservable from its considerations, and aims at describing the universe in terms of the observable and the merely practically unobservable only. It thus assumes omniscience, in the sense in which I have defined the word.

It will not take us long to see that physics includes the practically unobservable. No physicist denies that the moon has a far side in the same

sense as it has a near side. We assume without question that the earth has an interior, that there are stars outside the range of our telescopes, and regions beyond the obscuring clouds of the Milky Way. All these things could be observed if known means of observation have precisely the properties we believe them to have and we had the skill to make full use of them. Hence the practically unobservable is admitted to physical theory.

We may deal equally summarily with the logically unobservable. Nasty things have been said about the reasoning of some modern physicists when they step outside the bounds of their equations, but I do not think the bare, unadorned physical theories themselves have been called illogical, either with pride or with shame. If, then, the structure of physical theory allows ontological significance to anything which is logically unobservable, it does so through an oversight, and theory will undoubtedly be reformed as soon as the oversight is discovered. We may say, therefore, that the practice of physics is to reject the logically unobservable.

But now, the unobservables the rejection of which has caused all the controversy belong to neither of these classes. Let us fix our attention on the example of absolute simultaneity, with which the discussion began. This, as we know, is rejected, and that cannot be because it is practically unobservable, for physics reeks of the practically unobservable. Nor is absolute simultaneity logically unobservable. We can conceive that the universe might be such that two events at different places might occur at the same time in an absolute sense, and that this fact might be observable. We cannot, then, escape from the conclusion that absolute simultaneity belongs to a third class of unobservables, which we shall see is what I have called the class of physically unobservables; and the recognition of this class commits physics to the assumption of omniscience.

To see that absolute simultaneity is physically unobservable, let us look at the obstacle that prevents us from observing it. Why can we not say, in an absolute sense, that two events occurring at different places are simultaneous? It comes down to the fact that we can know of the events only through some agency which travels from them to us and takes time to do so. We know of most events when we see them, but we do not see them at the moments at which they occur because the light which makes them visible takes time to travel. We can, of course, allow for this by calculating how long the light has taken to travel, but when we do so, according to standard methods and principles, we find that the results depend on the way in which we happen to be moving with respect to the bodies on which the events occurred. Furthermore, we cannot distinguish in an absolute sense between one state of motion and another. Hence we do not know what allowance to make for the time of travel of the light, and therefore cannot determine absolutely whether the events were simultaneous or not.

The unobservability of absolute simultaneity, then, depends on the fact that we cannot determine unambiguously how long light takes to inform us of an event; or, more generally, how long after an event it is possible for us to know of it. This ignorance, of course, would not be necessary if we could know of an event immediately it occurred—if, this is to say, we could observe it by some messenger which travelled at an infinite speed. This is not pure fancy. Before the time of Römer, in the seventeenth century, it was believed that light might travel at an infinite speed; and before the theory of relativity arose, it was believed that gravitational action was transmitted instantaneously. It is not uncommon, too, to imagine that there might be instantaneous telepathic communication. We can at least, then, *conceive* that an instantaneous messenger might exist, and therefore absolute simultaneity is not *logically* unobservable. It is unobservable simply and solely because, so far as our present survey of the universe has gone, there is no evidence that it is possible to learn of a distant event at the moment at which it occurs. In other words, absolute simultaneity is *physically* unobservable.

We can now, at last, give a rigorous form to the principle which is the subject of our inquiry. It is this: that *only that which is practically observable*—that is, only that which would be observable if we were able to use known means of observation to the known limits of their possibilities—*is significant*.

The next step, clearly, is to examine the credentials of this principle on general rational grounds, but before doing so I want to give another example of its application, in order to emphasize the fact that it is not an unimportant appendage of physical theory, but the very mainspring of the most prominent modern developments. Heisenberg's uncertainty principle is perhaps the best-known example, but I will not deal with that because it is too closely bound up with other

factors which there is no time to consider. I choose instead a subject which stresses the point still more forcibly because it is not generally regarded as exemplifying the principle in question, but is attacked or defended on quite other grounds. The principle has taken root so deep in the minds of physicists that they employ it unconsciously, and justify their action by arguments which appear to others either incomprehensible or absurd. I am speaking of the idea that the physical universe is finite but boundless. This idea can be made intelligible in five minutes when presented as an example of the principle of rejection of the physically unobservable, and I believe that those who accept it are convinced of its rationality because they have already accepted that principle. They are not aware of this source of their conviction, however, and therefore have to justify their belief by saying that space is "curved", that it "bends back on itself"—an "idea" which I do not think it is humanly possible to grasp except as a metaphor of the kind one meets with in the "metaphysical" poetry of the seventeenth century. Whether or not that psychological diagnosis is accurate, however, is unimportant; the main point is to see that, in terms of our principle, the idea that space is finite and boundless is intelligible without calling on such unimaginable notions as curvature.

The idea is that if we were free to move about in space eternally, wherever Nature led, we would always find ourselves apparently in the midst of a collection of stars or nebulæ, though we could not for ever be meeting new objects, but would have to endure the tedium of seeing the old familiar faces endlessly, without relief. Like our former example, this idea, in its modern form, originated with Einstein; let us see how it has impressed his contemporaries. Sir Arthur Eddington, who thinks very highly of it, writes thus:

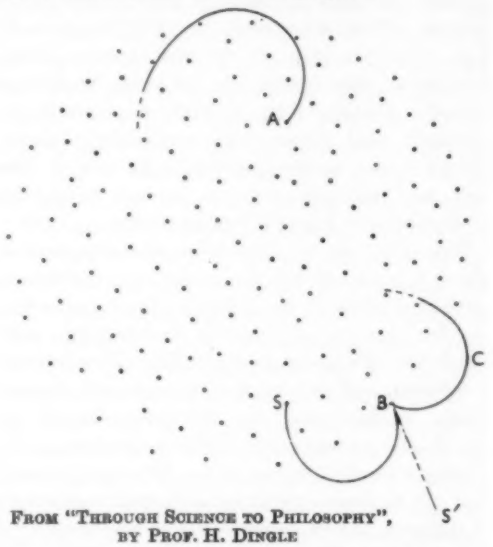
"Einstein made a slight amendment to his law to meet certain difficulties that he encountered in his theory. There was just one place where the theory did not seem to work properly, and that was—infinity. I think Einstein showed his greatness in the simple and drastic way in which he disposed of difficulties at infinity. He abolished infinity. He slightly altered his equations so as to make space at great distances bend round until it closed up."[6]

On the other hand, here is the stimulating Mr. Eagle again:

"In pre-Einsteinian days if people had been told that an author's theme in his book had been that external reality only possessed three spatial dimensions, and that therefore to talk of 'curved three dimensional space' was pure nonsense, they would have replied that they thought only lunatics thought otherwise. Now this conception is widely regarded in many circles as a 'probably may be true' one. This to me seems the measure to which both the scientific world and the general public have been bluffed by the theory. Future scientific historians will probably regard the theory as a befitting product of a mad age in the world's history."[7]

Prof. E. A. Milne is scarcely less contemptuous of this manifestation of Einstein's greatness.

"It is not necessary", he says, "to employ the vague, ill-understood, probably meaningless concept of closed, finite expanding space."[8]



From "Through Science to Philosophy", by Prof. H. Dingle

Well, the symptoms are familiar. Again we have the alternative estimates of supreme greatness and supreme folly, and we might suspect that the same misunderstanding is at the bottom of the trouble—as, in fact, it is. Let us begin with a finite collection of stars (or nebulæ) in a space which we suppose extends to infinity in all directions; we are somewhere in the midst of the collection—say, at *A* (see accompanying figure). Now suppose we try to get outside into the empty spaces. We cannot, because the gravitation of the system keeps all material bodies inside; the faster we move the greater is the attraction and we find ourselves following some such path as that shown in the diagram. It is the same with light; that also is drawn back, and cannot illuminate whatever external objects there may be. In fact, no physical existence that we know of can escape. All that is perfectly conceivable.

We picture, then, a finite universe from which we cannot escape. The next point is that it is impossible for us to know whether we are at its centre or its boundary; in either case we appear to be surrounded by stars on all sides. Obviously an observer at the centre (or at A) sees stars all round, but so does an observer at B, for the light of the stars inside is bent, so that he sees them whichever way he looks. The light of a star at S, for example, is bent so that the star appears to be at S'. This is a very ordinary phenomenon, exemplified every time we look at a mirror; an object appears in the direction of the light that enters our eye, and not necessarily where it actually is. We are therefore not only confined within the universe, but also necessarily without the possibility of the *experience* of being at the boundary; however we move, and wherever we go, we must always see the same kind of thing—stars more or less uniformly distributed all round.

All that is of the nature of simple, traditional physics: now comes the crucial point. Since the region outside the system is physically inaccessible and unobservable, and the *experience* of being at its frontier is physically unattainable so that it is never possible for us to know whether we are there or not, we leave these things outside our description of the universe. We give the name 'space' to the volume which contains what we can observe, and describe it simply according to our experience as both finite and boundless. We can still, of course, conceive that there is an infinite region outside (wherever 'outside' may be), but that is merely another way of saying that the region is not *logically* unobservable. The rejection of infinite space is, in fact, precisely similar to the rejection of absolute simultaneity: it represents an economy of ideas—we are to introduce no conceptions which are not necessary for the description of the physically observable.

It may be worth while to point out that this account of finite boundlessness differs from the statement that space is curved in the fact that it says nothing about any intrinsic *property* of space. There is no need to try to think of emptiness with a curvature; we have simply to think of possible experience, and keep within its bounds. Of course, for mathematical purposes the conception of curvature is useful because it allows us to employ the technique of Riemannian geometry to solve particular problems, and for the mathematician it may have some æsthetic value, as the poetry of Mr. T. S. Eliot is said to have for those "in the know". But for the purpose of understanding it is worse than superfluous; it is definitely misleading.

What, now, of the validity of this principle, which has taken charge of physics and threatens to direct all future philosophical thought? Let me repeat the principle: it says that *nothing which is logically or physically unobservable is significant*. This statement must be appraised on pre-scientific, general rational grounds, and we can best approach the task by returning to the rival arguments set out earlier and considering them in the light of our rigorous statement.

The essence of the argument for the principle is that it is needed to prevent arbitrary invention of existences or arbitrary dogmas about them; and it meets this requirement by saying, in effect, that everything that exists is observable by known means. The argument against the principle is that we have no right to assume omniscience; that although it may be granted that the logically unobservable cannot exist, it is presumptuous to say the same of the physically unobservable.

We are therefore in this dilemma. If we deny the principle, we have no check on idle invention; it may be that all that we know, and have taken such pains to find out, is trivial, while the great, important facts of the universe are not even suspected and are unattainable. On the other hand, if we accept the principle, we close the door to all experience outside that which our present knowledge allows. Let me repeat that this dilemma is not a domestic affair for physicists. In physics it concerns at present only existences observable by sense perception, but clearly it is equally relevant, in the appropriate forms, to all spheres of thought in which we regard ourselves as apprehending some independent existence by means of human faculties.

This last sentence, I think, gives the clue to the solution of the problem: "all spheres of thought in which we regard ourselves as apprehending some independent existence by means of human faculties". That is the attitude which I have assumed throughout this discussion—the attitude of naïve realism in which we picture an objective universe existing independently of our thought of it and our examination of it. It is the attitude which we always assume in everyday intercourse and in most scientific discussions also. We regard scientific research as an exploration of this independent universe, an attempt to discover what

it contains and to understand the pre-established relation of one part with another. It is this conception of science or philosophy that makes possible the dilemma by which we are faced. If the universe exists independently of our experience of it, then clearly it is presumption on our part to deny that it can contain anything inaccessible to experience. On the other hand, if we abstain from this presumption we make all inquiry a mockery, for we have no guarantee that anything that we may discover is more than a triviality, an insignificant part of a universe the essential elements of which are eternally unknowable.

But suppose we take the idealistic view, regarding our experience, our observations, as the primary data, and the universe as a mental construct formed to give rational coherence to those observations. The whole matter then appears in a different light, in which the dilemma is no longer seen. The statement that nothing which is logically or physically unobservable is significant is simply a statement of our aim as scientists or philosophers; it means that we confine ourselves to our purpose of deducing a universe from our observations and do not allow our fancies to intervene. There is no assumption of omniscience because there is no independent universe to know, and the arrogance disappears because we make no claim to know all the possibilities of observation. We set no limit to the possibilities of experience; we simply refuse to assert anything for which we have no (direct or indirect) justification in experience, and as observation grows the universe grows also. The objection to the principle therefore vanishes completely, from the idealistic point of view.

On the other hand, the objection to denying the principle by no means vanishes. If we do not exclude the physically unobservable from our description of the universe, we still have no grounds for not admitting the binkum and so reducing philosophy to a farce. When M. Maritain claims that a thing is independent of our observation of it, he immediately makes it impossible for us to know that we are saying anything of the least importance about it, no matter whether we adopt the realistic or the idealistic point of view. If we are realists the thing may be essentially beyond apprehension; and if we are idealists we may form it equally legitimately from observation or from fancy.

The position, then, is this. If we take the realistic view, we are left with an unresolved dilemma, but if we take the idealistic view, the principle becomes simply a statement of the object at which science has aimed throughout its history. It is not my purpose to comment on the age-old problem of idealism *versus* realism; I am concerned only with the attitude implied in modern scientific developments, and the point I want to emphasize as clearly and unmistakably as possible is that anyone who regards the recent trend of physics in general, and the theory of relativity in particular, as legitimate science or philosophy or intellectual activity bearing whatever name may be thought honourable, must either be an idealist or presume that he is omniscient. I do not wish in this place to plead the cause of either of the alternatives open to the humble. I am not anxious to cry, "Vote for realism, and down with relativity!" or "Support idealism and relativity, and throw realism to the dogs!". That is a matter for personal predilection, but it is a matter for pure reason to show that those are the only alternatives open to anyone who is not prepared to assume that he is omniscient.

The striking divergence of opinion with which we opened can now, I think, be understood. Those who, like M. Maritain and Mr. Eagle, see the principle in question as an example of presumption arising from ignorance, are realists—by which I mean that they instinctively think as realists, whether or not they would accept the title. On the other hand, those physicists and philosophers who accept the principle are, by the same criterion, idealists, though most of them speak our ordinary, everyday language which has accommodated itself to the realistic outlook. In terms of that language their utterances necessarily appear arrogant; what they apprehend instinctively as the wisdom of a self-imposed discipline is clothed in sentences which suggest to the realist the idea of arbitrary dogma. The divergence, arising as a difference of philosophical attitude, is accentuated by the necessity of expressing idealistic principles in realistic terms.

[1] "The Theory of Relativity" (English translation, p. 22) (1920).
[2] "Réflexions sur l'intelligence et sur sa vie propre", pp. 205–6 (1926).
[3] "The New Conceptions of Matter", pp. 23, 81 (1931).
[4] "The Philosophy of Religion versus the Philosophy of Science", pp. 169-70 (1935).
[5] "Philosophy and Logical Syntax", pp. 15, 17–18 (1935).
[6] "The Expanding Universe", p. 21 (1933).
[7] "The Philosophy of Religion versus the Philosophy of Science", pp. 219–20.
[8] *Z. Astrophys.*, **6**, 83 (1933).

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Literature of Food Investigation": 7, No. 1, March 1935. Compiled by Agnes Elisabeth Glennie, assisted by Gwen Davies. Pp. 371+xiii. (London: H.M. Stationery Office, 1937.) 5s. net); but it is hoped during the next twelve months to bring the "Index" up to date and to complete abstracts of the literature published in 1935 and 1936, which will form No. 2 of vol. 7, and vol. 8. Meanwhile the first number of vol. 9, containing abstracts of papers published during 1937, is in preparation. The papers noted in the present number are arranged in fifteen sections, and there is an author index extending to twenty pages. The compiler gives a brief review of developments during 1933–34, selecting the following subjects: gas-storage of meat and fruit, storage of rice, eggs, anti-oxidants for fats and oils, and engineering. Attention is directed to the fact that 1934 was the centenary of the invention of the earliest continuous refrigerating machine, by Jacob Perkin, which used ether as refrigerant, and was the first real landmark in the history of modern refrigeration, so far as technique is concerned.

Studies in Ancient Astronomy

A SMALL collection of papers recently published in *Meddelande Från Lunds Astronomiska Observatorium* makes an interesting contribution to the study of the early history of astronomy. In an article entitled "Greek Cosmogony and Astronomy", Dr. K. Lundmark briefly traces the development of Greek astronomy from the first indications of some primitive astronomical knowledge found in the Homeric poems and in the work of Hesiod to the great work of the Alexandrine astronomers and mathematicians, culminating in the production of the "Almagest" in the second century A.D. A very useful synopsis for rapid reference is included of Greek astronomers and their contributions to astronomical ideas and observation. In another paper, P. Collinder studies the distribution of the birthplaces of the astronomers of antiquity. He remarks that the Hellenic peninsula itself produced but few in contrast with the west coast of Asia Minor, with Alexandria and the coast of southern Italy. It was, in fact, in the great merchant and shipping towns of these latter localities where the Greeks would best receive the importation of astronomical knowledge from the Babylonians, Egyptians and Phœnicians. A further contribution by B. Svenonius describes his examination of certain rock sculptures found in Ostrogothie, Sweden. These engravings, which may date from the bronze age, include amongst the representations of men, animals, ships and primitive weapons, groupings of small cavities, which it is agreed represent groupings of the bright stars into constellations. M. Svenonius identifies the following constellations: the Great Bear, Cassiopeia, Perseus, Cepheus, Auriga, Orion and Leo. An examination by earlier Swedish investigators of similar rocks found in Bohuslän leads to the same general conclusion that the forms of several easily recognizable constellations were copied by some of the prehistoric watchers of the skies. In a supplementary note, A. Ohlmarks contributes remarks on these rock engravings and their relation to the history of early religious beliefs.

Physics Research at Osaka

THE volume of *Collected Papers* for 1936 from the physics section of the Faculty of Science of Osaka University includes 33 papers which have appeared in scientific periodicals between February 1936 and March 1937. The papers are in their covers as issued as reprints and are bound together with wire to constitute the volume, which is 10·1 in. × 7·4 in. × 1 in. Twenty-two of them are from the *Proceedings* of the Physico-Mathematical Society of Japan, five are Reports of Radio Research in Japan and two are from the Institute of Physical and Chemical Research, and five other institutions contribute a paper each. The papers from the Physico-Mathematical Society are nearly equally divided between problems of atomic structure and radiation, hydrodynamics and electricity. A table of contents is provided in which each paper is numbered and the number is printed on the right hand top corner of the cover of each so that reference is easy. The various publications from which the papers are reproduced appear to have very nearly the same size of page, slightly larger than that of the volume, except in one instance in which the page is 0·2 inch less wide. This inexpensive form of issuing collected papers seems to be on the increase.

Films for Promoting International Understanding

IN *Film Progress* of July, the Central Information Bureau for Educational Films, Ltd., announced the impending release of "Living in Wales", the second of its series of talking films designed to help the peoples of the world to gain a clearer insight into each other's lives and thereby to promote sympathetic mutual understanding. The first of the series, "Living in the Netherlands", is reported to have been well received both at The Hague and in London. "Living in Wales" was used at the Congrès Internationale de l'Enseignement Primaire et de l'Education Populaire to illustrate an address by Dr. G. H. Green of Aberystwyth on "The Cinematograph as a Means of Education for International Understanding". The paper emphasizes the fact that the educational film is not merely an additional means of illustrating or confirming what the teacher conveys through the medium of words, but also provides the closest possible approximation to real first-hand experience. It postulates four essentials for the success of films as instruments for promoting international understanding: an adequate supply of suitable trustworthy films, efficient machinery for production, distribution and publicity, comprehensive experiments and investigations into the technique of education by means of the film, and a centre for acquainting teachers not merely with the films and projectors available but also with all matters relating to films. The same issue of *Film Progress* announces the decision of Osaka City authorities to build an "Educational Movie Hall" at a cost of 500,000 yen for the benefit of primary school pupils.

Economic Aspects of the Cotton Trade

"WORLD COTTON PRODUCTION AND TRADE" is the first of a series of studies of the principal agricultural products on the world market to be published by the International Institute of Agriculture, Rome (price 30 lire). This comprehensive monograph, consisting of 480 pages and 20 maps and diagrams, is divided into four main sections. The first deals with the geography of cotton production, describing the agricultural conditions of the humid and sub-humid zones of the rain-grown crop, and the arid or semi-arid zone of irrigated cotton. Part 2 describes the conditions of cotton marketing and movements of cotton prices, while Part 3 is concerned with the evolution of world cotton trade. The fourth part deals with the national and international aspects of the industry, separate sections being devoted to the principal countries concerned. It is evident that the economic problems of the cotton trade are closely linked up with the wider financial and commercial problems of the world. The relatively large expansion of the smaller cotton countries during an economic crisis simultaneously with the general contraction of the world cotton industry, presents one of the most significant aspects of the world economic problem. The position was aggravated by the policy of the United States of maintaining cotton prices at an artificially high level and closing their market to European goods. It is considered that from the point of view of a rational world economic system, the various branches of agriculture should be developed in those parts of the world which are most suitable. Under such a system the United States would regain its position on the world cotton market, which is regarded as its full right, but the conditions of such a recovery would be the abandonment in all countries of the prevailing tendency towards economic isolation and a development of a greater degree of international co-operation.

Progress in the Meteorological Office

THE eighty-second year of the Meteorological Office is referred to in the annual report of the Director for the year ended March 31, 1937, as one of planning and preparation with the object of providing the greatly extended meteorological services required by the expanding Royal Air Force and by the increase of flying on civil air routes. These projected increases of meteorological activity have made it necessary for new staff to be recruited and trained in the special work required of them; in particular, the need for trained forecasters has had to be met in order to staff the principal forecasting centres on the various flying routes. The new Empire Air Mail Scheme led to the formation of a new division of the Meteorological Office in 1935 to organize the meteorological services of the trans-Atlantic and Empire air routes, the duty of advising the Governments of territories traversed by the routes having devolved on the Meteorological Office, and throughout the year under review that division was preparing for the new mail service. The forecast and aviation division has given particular attention to the information required by civil and R.A.F. aircraft in connexion with flying in and through clouds—information about the winds to be expected and warnings of dangerous conditions likely to lead to ice accretion between certain heights in strata where temperature lies between 0° F. and 35° F. and other circumstances are favourable for such accretion. It has now been determined that really dangerous conditions are scarcely ever found when temperature is more than a few degrees above or below the freezing point.

Motor Traffic and Wild Life

IN a discursive and interesting paper read before the Zoological Society of London (*Proc. Zoo. Soc.*, Ser. A, 173; 1937), Surgeon Rear-Admiral Beadnell has given an indication of the destruction of wild creatures caused by motor traffic in Great Britain. In the years 1932–36, in travelling by motor-car and pedal-cycle on roads in England, Wales and Scotland, he counted 2327 dead animals in 10,000 miles, or 23 in every hundred miles. The kill was made up in the following proportions: birds 81 per cent (1885 individuals), rabbits 14 per cent, hedgehogs 4 per cent, rats 0·5 per cent, and the remainder was made up of frogs, toads, moles, snakes, dogs, cats, two sheep and one forest pony. It may be taken that the number counted during a rapid survey falls far short of the total number slain, and indeed were it not that many motorists when driving are highly regardful of wild creatures, the number would be much greater than it is. But the count does not suggest that motor traffic will make appreciable inroads upon the stock of wild animals, for the numbers are insignificant compared with the rate of increase of the common species which usually fall victims. An odd death which came to the notice of the writer was that of a dog fox in beautiful pelage, which during a snowstorm in the north-east of Scotland leapt over a stone wall against the wings of a heavy lorry.

Policy in Pig-Feeding

THE pig and bacon industry in Great Britain is dependent upon imported and home-grown cereals, and during the last twelve months feeding costs have risen by 30 per cent without a compensating rise in the price of bacon. The Bacon Development Board has accordingly completed an inquiry into the possibility of replacing cereals by other foodstuffs, and the report of A. N. Duckham has been published as Bulletin No. 2, "Substitutes for Cereals in Pig-Keeping" (Bacon Development Board, 1937. Price 2*s*.). The general conclusion is that if some sacrifice of growth rates and carcass quality is allowed and adequate facilities for growing and storing substitutes are made available, then cereals may be replaced in part by potatoes, sugar-beet and other home-grown root and fodder crops or by-products either in fresh or processed forms. At present, the use of these cereal substitutes may not be economical in Great Britain, but conditions may arise when cereals, home produced or imported, may be in short supply or at greater cost, and under such conditions it is

believed that pig production could be kept up as an economic proposition, making an appreciable contribution to the national supply of meat and animal fat for human consumption.

Water-Power of the World

THE United States Geological Survey has attempted a new estimate of the potential and developed water-power resources of the world. The estimate is based on ordinary medium flow and 100 per cent efficiency. Potential power is based on existing flow and disregards storage except in the case of constructed reservoirs. The estimates for developed power are based on installed capacity of machinery at constructed plants, which averages two or three times the potential power at low flow at the same sites. Thus, for example, the potential power at utilized sites in France amounts to 21 per cent of the total potential power of that country, but in effect amounts to 44 per cent of the theoretical total power resources. With this proviso, it is noted that about ten per cent of the potential water-power of the world is developed. The capacity of the constructed plant in the world at the end of 1936 was 60 million horse-power, or an increase of 160 per cent in sixteen years. The United States show by far the greatest development, but Canada, France, Italy and Japan have high figures, and Norway, Germany, Sweden, Switzerland and the Soviet Union show rising totals.

Biochemistry in India

THE Society of Biological Chemists, India, publishes a useful review each year of the results of investigations in biochemical subjects which have been carried out in India during the previous twelve months. The current number (*Annual Review of Biochemical and Allied Research in India*, 7, 1936. Pp. 165. (Bangalore: Society of Biological Chemists, India, 1937.) 3*s*.) is divided into seventeen sections, of which about two-thirds are devoted to various aspects of agricultural science. Sections are also given to vitamins and hormones, pharmacology and human physiology, pathology and bacteriology. The papers reviewed have, of course, been published in full in other journals, chiefly Indian, but this volume provides a useful summary of work which is not always easily accessible. It is noticeable that the size of the volume has been increased considerably since this review was first published, a tribute to the steady progress research is making in India.

Diseases of Fur Animals

THE United States Department of Agriculture, Washington, D.C., in Farmer's Bulletin No. 1777, gives an account of the diseases attacking fur-animals on the farm, together with methods of control. Descriptions are given of distemper, paratyphoid infection and encephalitis of foxes, of hookworm, tapeworm and fluke affections, and of external parasites such as fleas, lice and sarcoptic mange, as well as of nutritional disturbances. Useful information is also given on farm sites and structure, their sanitation and disinfection. The Bulletin should be of value to those engaged in the fur industry in Great Britain.

Fire at Messrs. Flatters and Garnett, Ltd.

A SERIOUS fire occurred on Sunday morning, December 19, at the laboratories of Messrs. Flatters and Garnett, Ltd., the well-known Manchester firm of microscopists. The chemical and microscopical laboratories were completely burnt out, but a considerable number of mounted slides were saved. The photographic and lantern slide department was only slightly involved and the new instrument workshop, for manufacturing microscopes, micro-projectors, etc., escaped entirely. All the staff is being retained, and work has already been resumed in temporary laboratories. Stocks of most of the firm's chemical specialities are held at the head office, 309 Oxford Road, Manchester, 13, which is two miles from the laboratories.

Awards of the Institution of Naval Architects

THE Council of the Institution of Naval Architects has awarded the premium of the Institution for the year 1937 to Mr. R. W. L. Gawn, for his paper "Results of Experiments on Model Screw Propellers with Wide Blades", the Wakeham Prize (1937) to Mr. H. Lackenby, for his paper "Re-analysis of William Froude's Experiments on Surface Friction and their Extension in the Light of Recent Developments", and the Duke of Northumberland Prize (1937) (awarded by the Council of the Institution in connexion with the award of National Certificates in Naval Architecture) to Mr. D. N. Wallace, of the Royal Technical College, Glasgow.

International Federation of Eugenic Organizations

THE report of the Twelfth Conference of the International Federation of Eugenic Organizations, held at Scheveningen, Holland, in July 1936, has just been issued, and can be obtained from W. P. van Stockum and Zn., N.V., The Hague, Holland, price three Dutch florins. A list of the fifty delegates from twenty countries is followed by twenty-five papers presented at the meetings. The papers range from the classification and inheritance of mental defects to mutations in plants and man, twin studies and the problems of sterilization in Germany, Denmark, Sweden and the United States. The 119 pages end with a report of the Human Heredity Bureau and also reports on the standardization of measurements in anthropometry, physiometry, psychometry and on racial psychiatry.

Fifth International Congress for Experimental Cytology

THE fifth Congress for Experimental Cytology will be held in Zurich on August 7–12, 1938. The sixteenth International Physiological Congress and the International Veterinarian Congress will be held in Zurich too, on August 14–18 and August 21–25 respectively. The proceedings of the Cytological Congress are not to be divided in sections, but will be organized in the following way: Scientific sessions will take up seven half days; two afternoons are reserved for demonstrations, and during one afternoon there will be an excursion. Special subjects are to be treated at each session, opening with a general

review to which one or two supplementary reviews may be added. Reprints of these papers will be sent to the members of the Congress at their home addresses, or—at the very latest—will be handed over to the members at the opening sessions of the Congress. Copies of the individual papers are likewise to be distributed before the sessions, the main object of this Congress being the discussion of cytological topics of special interest. The following subjects have been chosen for review: epithelium in culture and in the organism; structure of chromosomes; mechanism of mitosis; cancer cells and normal cells; experimental research on cytology and viruses; ultra-structure of the protoplasm and its products; chemistry of the cell. Further information can be obtained from the honorary secretary for the Congress, Dr. Harald Okkels, Institute for Pathological Anatomy, University of Copenhagen, Denmark.

Congress of Anthropological and Ethnological Sciences

FURTHER arrangements are announced for the second International Congress of Anthropological and Ethnological Sciences, which will be held in Copenhagen on August 1–6, 1938 (see NATURE, July 24, 1937, p. 147). This date has been chosen to meet the convenience of any members who may also attend the International Congress of Geography at Amsterdam on July 18–28. The proceedings at Copenhagen will take place in both general and sectional meetings. There will be eight sections, and a number of subsections, each being devoted to some one branch of anthropological study with a special topic proposed for discussion, though this does not preclude the acceptance of communications dealing with other matters. Among the topics proposed, the following may be mentioned: under Physical Anthropology, in the subsection of Anatomy and Biotypology, meeting under Prof. H. M. Houdensen—interrelation of types of fossil man, methodology, and the conception of 'race' in anthropology; Subsection of Physiological Anthropology, under Prof. Oluf Thomsen, geographical distribution of blood groups in man and their presence in animals; in the Section of Psychology, under Prof. Edgar Rubin, influence of the factors of civilization on character and (with the Section of Sociology and Religion) on cultural changes; in the Section of Ethnology, under Prof. Gudmund Hart, origins of agriculture and the domestication of animals and plants; in the Section of Ethnography, in the subsections of Asia and Africa, of which M. C. G. Feilberg, curator of the Ethnographical Museum and M. Carl Kjersmeier are the respective presidents, the nomad pastorals of Asia and Africa; in the subsection of Arctic Ethnography, under Dr. Therkel Mathiassen, the prehistoric and historic culture-movements of the circumpolar region; and in the Section of Sociology and Religion under Prof. Wilh. Grønbech, the extent to which archæology and prehistory can serve as a basis for the study of intellectual development. Applications for membership should be addressed to the Treasurer of the Congress, Nationalmuseet, 10 Ny Vestergade, Copenhagen, K.

National Parks of the Belgian Congo

THE Institute of the National Parks of the Belgian Congo, Brussels, has decided to publish a collection of photographs of the vegetation of these parks, and has commenced by issuing a very fine series of photographs of the general aspect of the vegetation of the Albert National Park, which comprises some 900,000 hectares in the heart of tropical Africa to the north of Ruwenzori and including several volcanoes. The photographs, taken during the expedition of G. F. de Witte (1933–35), are excellent, and they are beautifully reproduced in the first number of this new production (Vol. 1, Fascicules 1 and 2, Plates 1–12, Brussels, 1937): they include some striking examples of arborescent species of *Senecio* and giant *Lobelia*.

Announcements

PROF. James P. Kendall, professor of chemistry in the University of Edinburgh, has given 1,000 dollars to the American Chemical Society for the 1938 American Chemical Society award in pure chemistry. The award, established in 1931 by A. C. Langmuir to encourage creative work in pure chemistry by men of science at the beginning of their careers, will be made for 1938 at the Society's spring meeting in Dallas, Tex., on April 18–21. The age limit, hitherto thirty, has been raised to thirty-five years. Prof. Kendall was professor at Columbia University from 1913 until 1926, and afterwards head of the department of chemistry at Washington Square College, New York University.

A SERIES of two popular lectures by Prof. C. E. Inglis, entitled "Building Big Bridges", has been arranged by the Engineering Public Relations Committee, primarily for those between the ages of 15 and 20 years. The lectures will be given on January 7 and 10 at 3 p.m., at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Application for tickets, which are free, should be made to the Public Relations Officer, Engineering Public Relations Committee, 1–7 Great George Street, Westminster, S.W.1.

DR. B. L. BHATIA, formerly assistant professor of zoology at the Government College, Lahore, and later principal of the Government College, Hoshiarpur, and author of works on Ciliophora and Sporozoa in the Fauna of British India series, has established "The Science Press of India" as a science news agency for the daily Press in that country. His address is Hotusingh Road, Lahore.

CATALOGUE 15 B (II) of laboratory balances, issued by Griffin and Tatlock, Ltd., contains particulars of a wide range of analytical balances (ordinary, aperiodic, projection-reading, chainomatic) and a noteworthy selection of micro-analytical balances. The catalogue also includes weights, scales and spring balances. A very cheap silica-gel desiccator to replace calcium chloride in balance cases, which lasts indefinitely, is listed.

Letters to the Editor

The Editor does not hold himself responsible for opinions expressed by his correspondents. He cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 40.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Fusions between Flexuous Hyphæ and Pycnidiospores in *Puccinia graminis*

IN 1933, Craigie[1] discovered that from the mouth of a pycnidium of *Puccinia helianthi* or of *P. graminis* there project not only many straight pointed hair-like cells known as periphyses but also a number of hyphæ which had previously been overlooked and which he called *flexuous hyphæ*; and in *P. helianthi*, some hours after he had mixed the pycnidiospore-bearing nectar of (+) and (−) pycnidial pustules, he observed that some of the flexuous hyphæ had each fused with a pycnidiospore presumably of opposite sex. In 1933, Pierson[2] reported that he had seen similar fusions in *Cronartium ribicola*.

Recently, after mixing the pycnidial nectar of *Puccinia graminis* (the parasite that causes the Black stem rust disease of wheat), I have observed from eighty to a hundred fusions between a flexuous hypha of one sex and a pycnidiospore of opposite sex. No fusions between periphyses and pycnidiospores were seen.

A vertical section through a barberry leaf showing intercellular mycelium and three pycnidia all derived from a single basidiospore of *Puccinia graminis*, and therefore all haploid, is shown in Fig. 1. The main body of a pycnidium is situated beneath the epidermis of the leaf, and consists of a wall bearing pycnidiosporophores from which numerous pycnidiospores are cut off terminally and of a chamber into which the pycnidiospores are set free. The spores have gelatinous walls which swell up and so cause the spores to be extruded at the mouth of the chamber. From the ostiole of each pycnidium is excreted a drop of nectar which, by its scent and sugary contents, is made attractive to insects. In Fig. 1, the three drops of nectar have become confluent. Into the nectar, each pycnidium sends out about 60–70 periphyses (straight pointed red hairs) and a smaller number of flexuous hyphæ, some of which are branched. In Fig. 1 these hyphæ can be seen projecting beyond the clouds of gelatinous spores into the clear part of the nectar.

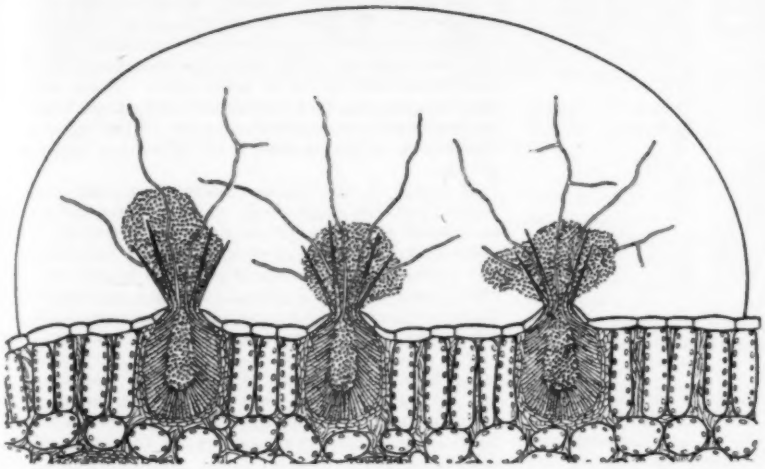


Fig. 1.

Puccinia graminis IN A LEAF OF *Berberis vulgaris*. VERTICAL SECTION THROUGH THE UPPER PART OF A PYCNIDIAL PUSTULE SHOWING: (1) THE UPPER EPIDERMIS, THE PALISADE LAYER, AND SOME SPONGY PARENCHYMATOUS CELLS OF THE LEAF, AND (2) SOME OF THE INTERCELLULAR MYCELIUM AND THREE PYCNIDIA OF THE FUNGUS. THE PYCNIDIA ARE COVERED BY A COMMON DROP OF NECTAR INTO WHICH PROJECT FROM EACH PYCNIDIUM A MASS OF GELATINOUS PYCNIDIOSPORES, POINTED PERIPHYSES, AND SEVERAL FLEXUOUS HYPHÆ. HIGHLY MAGNIFIED.

Several hours after the pycnidial nectar had been mixed, transverse sections of the living leaf and pycnidial pustules were made with a hand-razor, and the sections were at once mounted in water and observed with the microscope. Thus fixing and staining methods were avoided, and the fused hyphæ and pycnidiospores were seen in the living state.

The fusion of a flexuous hypha with a pycnidiospore may take place at the end of a flexuous hypha, as shown in Fig. 2, or at the side of a flexuous hypha, as shown in Fig. 3. In the latter case the flexuous

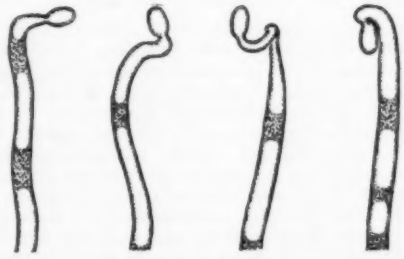


Fig. 2.

THE ENDS OF FOUR FLEXUOUS HYPHÆ WHICH HAVE EACH FUSED WITH A PYCNIDIOSPORE. × ABOUT 500.

hypha sends out toward the spore a special branch or fusion peg. Soon after a fusion has taken place (3–6 hours after mixing the nectar), the main protoplasmic contents move out of the pycnidiospore and out of that part of the flexuous hypha which has fused with the spore, thus leaving behind a large vacuole. Presumably the nucleus of the pycnidiospore passes down the flexuous hypha toward the fundaments of the æcidia. This passage is made easier by the fact that the flexuous hyphæ have no septa.

The fundaments of the æcidia or 'rudimentary æcidia' which, after the nectar of (+) and (−) pustules has been mixed, become diploidized and produce æcidiospores, are well-defined haploid organs. They require a special name, and I therefore propose that they should be called *proto-æcidia*[3].

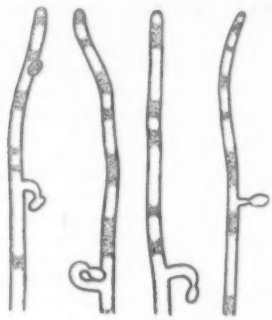


Fig. 3.

FOUR FLEXUOUS HYPHÆ WHICH HAVE EACH SENT OUT A SHORT BRANCH OR PEG WHICH HAS FUSED WITH A PYCNIDIOSPORE. × ABOUT 500.

The experiments here recorded were made early this year at Winnipeg in the Dominion Rust Research Laboratory, and I here wish to acknowledge my indebtedness to Dr. J. H. Craigie for placing the resources of the laboratory at my disposal and to Dr. T. Johnson for supplying me with a series of inoculated barberry bushes.

A. H. REGINALD BULLER.

The Herbarium,
Royal Botanic Gardens,
Kew. Nov. 30.

[1] Craigie, J. H., NATURE, **131**, 25 (1933).
[2] Pierson, R. K., NATURE, **131**, 728–9 (1933).
[3] A more detailed account of the sexual process in *Puccinia graminis* and other rust fungi is in preparation for vol. 7 of my "Researches on Fungi".

Nature of the Outer Surface of the Cell Walls of the Mesophyll of the Leaf

IN a recent communication[1], it was recorded that a number of hydrocarbons, including pure paraffin, readily entered the air-spaces of a leaf strip placed vertically in contact with the surface of these liquids, and could also be observed to flow readily over the surface of the exposed mesophyll and cascade down and fill the interspaces. Water, on the contrary, will neither flow over the surface nor fill the interspaces under any conditions, without a pressure gradient.

Since then, working independently, I have found that certain dyes such as janus green, which are also sensitizers of protein monolayers, are strongly adsorbed on the surface of the cells when the leaf is infiltrated under pressure. Under these conditions, it was found that ready infiltration of the air-space could be obtained, but the dye was entirely adsorbed on the cell walls near the point of entry, while the leaf lamina although completely infiltrated by water was entirely free from dye. The dye so adsorbed cannot be liberated by water on exposure of the mesophyll, although it can be extracted by acetone as was described by Ponder[2] for red corpuscles sensitized with brilliant green. The dye cannot be extracted in water by a rise of 15° as recorded by this author for the protein layers of red corpuscles. This possibly may be due to the fact that adsorption took place at a laboratory temperature of 33° instead of 15° as in Ponder's observations on red corpuscles.

Dyes such as methylene blue, neutral red, diamantfuchsin, jodgrun, indigo carmine all give the same results. Other dyes such as orange G, congo red, nigrosin, corallin and magdala red enter the interspaces with the water and show no adsorption.

On using a mixed solution of non-adsorbed and adsorbed dye in approximately equal concentration, the protein adsorbed dye is entirely adsorbed near the point of entry while the other dye enters and fills the interspaces and shows no adsorption. These results are obtained equally well whether the leaf is infiltrated by dye drawn in from the cut edges of the lamina, or whether it is drawn into a complete leaf from the petiole.

If one of the fatty acids such as sodium taurocholate in slight bulk concentration in water be placed on the exposed mesophyll, it begins to spread, and after an interval of one or two minutes the bubbles of air in the interspaces below are displaced and the liquid spreads out and gradually fills the interspaces of the mesophyll. The action is exactly similar to that observed with pure paraffin but the rate is very much slower. Leaf strips placed vertically with the edge in contact with the fatty acid solution are slowly infiltrated, but the process is arrested about 5 mm. from the point of entry, when a brown band of discolouration appears at the limit of infiltration.

The action of the fatty acid on the exposed mesophyll is sensitive to *p*H reactions, as was found by Schulman and Rideal[3] in their observations of the lytic action of fatty acids on protein monolayers in red cells. In this case, the action proceeds readily at a *p*H of 6·2 but very slowly if at all on the alkaline side, while the reverse was recorded for red cells.

The unwettability of these cell walls by water and their great adhesion for hydrocarbons shows that the surface is not covered by liquid water. The strong adsorption of protein sensitizing dyes in general and the non-adsorption shown by other dyes strongly suggest that the outer cell wall–air interface is not a cellulose surface.

The fact that fatty acids which have the power of entering and dispersing protein monolayers cause complete wettability of the walls by water only within certain *p*H values, suggests that the interface may be protein in nature and of molecular thickness.

It is hoped to publish the results shortly.

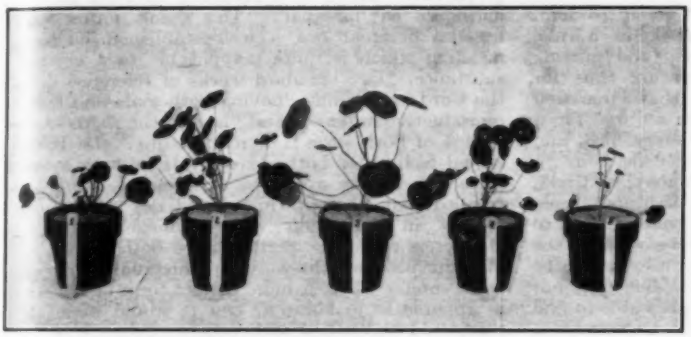
F. J. LEWIS.

Department of Botany,
Faculty of Science,
Egyptian University,
Abbassia, Cairo.
Nov. 21.

[1] Bangham, D. H., and Lewis, F. J., NATURE, **139**, 1107 (1937).
[2] Ponder, E., *Proc. Roy. Soc.*, B, **103**, 556 (1928).
[3] Schulman, J. H., and Rideal, E. K., *Proc. Roy. Soc.*, B, **122**, 46 (1937).

Physiological Curve of Response to Plant Growth Hormones

THE addition of growth hormones to a variety of plant materials results in marked responses over appropriate concentration ranges. The behaviour



EFFECT OF GROWTH HORMONE ON NASTURTIUMS. LEFT TO RIGHT: 50 C.C. DAILY NUTRIENT SOLUTION ONLY; SAME, CONTAINING 1/100, 1/10, 1 AND 2·5 P.P.M. 1-NAPHTHYLACETIC ACID RESPECTIVELY.

varies with the particular hormone used, the method of application and the developmental stage of the plant. With graded concentrations of growth hormone the response assumes the form of a physiological curve.

The accompanying photograph shows the characteristic curve obtained with nasturtiums. After fourteen days growth in soil, these plants were transferred to sand in 4-in. pots and treated for twenty-three days in the manner indicated. Marked stimulation in growth at low concentrations is followed by damage as the amount of growth hormone is increased to excess. A physiological curve of this sort is known to be characteristic of the responses which are obtained with a number of different plants, including certain lower plant forms, such as yeast.

Marked increase in the rate of growth is obtained by the addition to the soil of exceedingly small quantities of the active chemicals. The green weight of tops of 8-weeks old lettuce plants was increased more than 300 per cent by the addition of the equivalent of 150 mgm. of 1-napthylacetic acid to an acre. This particular result was obtained by applying appropriate quantities of 1/100 p.p.m. solution at intervals of three days.

The dusting of seeds with growth hormones incorporated in a suitable diluent carrier caused substantial increases in both top and root development. This method of application is particularly advantageous; as it supplies the active chemicals gradually, and avoids the inhibition of root growth which usually results from a solution method of treatment.

A paper on this subject will appear shortly in the *Canadian Journal of Research*.

N. H. GRACE.

Division of Biology and Agriculture,
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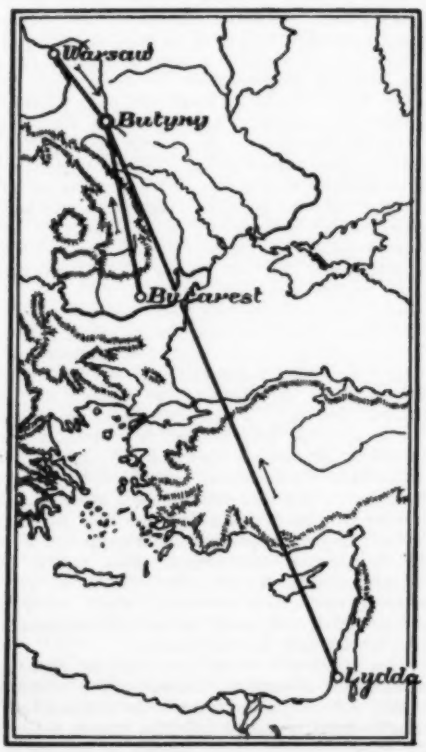
Ottawa.
Nov. 19.

Experiments on Homing in Birds

EXPERIMENTS on homing in birds were made by one of us[1] for the first time in 1933. These showed that wild birds, especially swallows, have more sense of orientation and are better able to find their homes than even carrier pigeons. Later on, Rüppell[2] established as a result of a series of experiments that swallows could find their homes from distances as great as 1,850 km. The same applies to starlings and wrynecks.

This year we experimented on white storks for the first time. In one test they were taken 50 km. and 111 km. away from Butyny, near Lwów; in another series of tests the birds were transported by aeroplanes (Polish Airways "L.D.T.") from Butyny to Warsaw, Bukarest and Lydda in Palestine, 300 km., 660 km. and 2,260 km. respectively. These distances are all along the airline shown in the map below. The birds were specially marked in bright colours and also ringed, so that it was comparatively easy to recognize them after their return to their nests and young.

The results confirmed that 75 per cent of the birds tested came home safely. The average speed of their journey was one third slower than the speed of swallows over small distances, although it equalled



the speed of swallows over big distances, such as 2,260 km. It should be borne in mind that the flight of the stork differs greatly from that of the swallow. The daily rates of progress did not vary to any great extent. The extremes vary: 165 km. for birds released in Bukarest and 188 km. for birds flying from Lydda.

The behaviour of the birds, when given freedom, was much the same and characteristic as a rule. They all took their time in cleaning and putting their feathers in good order, preparing thus for flight. Having taken to the wing, they circulated above the place where they had been set free for a time which varied practically with every bird, and then every bird took a proper direction for home.

As a result of these experiments we may, we think, regard it as a fact that some species of birds possess a special sense of orientation, which enables them to trace their homes from great distances without the help of kinesthetical factors. It is also not to be doubted that 2,260 km. in a straight line does not constitute the limit from which birds are able to find their homes.

KAZIMIERZ WODZICKI.
Department of Anatomy, WŁ. PUCHALSKI.
College of Agriculture, H. LICHE.
Warsaw.
Nov. 15.

[1] *Acta Ornithologica Mus. Zool. Polon.*, **1**, 8 (1934).
[2] *J. Ornithologie*, **85**, 1 (1937).

Terminology of Sex Hormones

ONE hesitates to advocate the use of new words, even in a rapidly growing subject such as endocrinology, but obvious anomalies are becoming evident in the description of certain activities of the sex hormones, and there is good precedent for supposing that an improvement in terminology would not only be desirable in itself but also would help to clarify the position. One may recall, for example, that the introduction of the words 'œstrogenic' and 'androgenic' has done much to promote clear thinking and precision of expression. The application of the word 'œstrogenic' to the biological activities of œstrone, and 'œstrogen' to substances having œstrogenic properties, was of course due to the best-known property of the hormone, that of causing changes characteristic of œstrus.

These terms serve a very useful purpose, but it is now evident that they are inadequate. Thus the power of œstrogens to cause feminization of the plumage of birds, especially as hen-feathering is rarely cyclic in the female, can scarcely be called œstrogenic activity. I suggest, therefore, that the word *gynæcogenic* be used as a general term to describe activity which results in the production of the attributes of femaleness, and the word *gynæcogen* to describe a substance having such activity, œstrogenic and œstrogen being applied only to the production of œstrous changes. The capacity of many of the androgenic substances to cause growth of the uterus and mucification of the vagina would then indicate gynæcogenic activity, while *trans*androstenediol, which will cause actual cornification of the vagina, would also be œstrogenic.

Certain properties of œstrone, such as its capacity to correct the castration changes in the pituitary of the male rat, to cause fibrous development of the seminal vesicles or to cornify the uterus masculinus of the rhesus monkey, are difficult to include in any terminology, though the first might be called androgenic activity, and the latter œstrogenic activity if the 'uterus masculinus' of the rhesus monkey is actually a vagina masculina.

A further point concerns the terminology of hormones which have both androgenic and gynæcogenic properties. There is a tendency to refer to such hormones as 'bisexual'. This seems unfortunate, because bisexual has a well-established biological meaning which is quite inapplicable to a chemical substance. Two standard works of reference define the word as meaning "having both male and female reproductive organs"[1], and "having the reproductive organs of both sexes; hermaphrodite; also having sexual feeling for both sexes"[2]. In seeking a more suitable word to apply to a hormone, it may be recalled that Champy[3] introduced the word 'ambosexual' in connexion with plumage and other characters to imply "pertaining to both sexes", and Witschi[4] has used the word 'amphisexual' in a somewhat similar way. A more correct form of the word is apparently *ambisexual*, and it would seem that this could be applied with perfect propriety to substances, extracts and organs which exhibit activities pertaining to both sexes. Thus testosterone would be a hormone with ambisexual properties, possibly, though less correctly, an 'ambisexual hormone', while the testis and the ovary, each having potential endocrine activities related to the function of the opposite sex, would be organs with ambisexual activities.

Finally, reference may be made to 'gonadotropic', 'thyrotropic', etc., which have served a useful purpose for some years and now show signs of becoming indispensable. Burn[5] has recently pointed out that the suffix 'tropic', as used to indicate hormones which stimulate the growth of particular organs, is quite incorrect, and he has since suggested that 'trophic' would be much more suitable. It is clear that the alteration would effect a useful improvement in terminology with little or no trouble to writer or reader, and it is therefore desirable from every point of view. *Gonadotrophic* has already been used by certain investigators[6], and I venture to hope that this form, together with *thryotrophic*, *adrenotrophic*, etc., may become customary.

A. S. PARKES.
National Institute for Medical Research,
Hampstead, London, N.W.3.
Dec. 11.

[1] Henderson and Henderson, "Dictionary of Scientific Terms" (Oliver and Boyd, 1920).
[2] Dorland, "American Illustrated Medical Dictionary" (Saunders, 1935).
[3] Champy, Bulliard, Kritch, and Demay, *Arch. d'Anat. micr.*, 27 (1931).
[4] Witschi, *Bull. Soc. Biol. Lett.*, **5**, 79 (1936).
[5] Burn, "Biological Standardisation" (Oxford Medical Publications, 1937).
[6] See for example, Tenney and Parker, *Endocrinology*, **21**, 687 (1937).

Faraday on Electromagnetic Propagation

THE significance of Faraday's sealed packet of 1832, opened recently at the Royal Society, is not any potential claim for priority which would be quite foreign to his nature, but the remembrance of an episode of ten years earlier which continued to rankle; he was then suspected of having overheard a discussion at the Royal Institution laboratory about how to produce electromagnetic rotations, which put him on the track of his beautiful solution of that

problem and thus produced in fact the earliest electric motor. He was resolved that such suspicion should not occur again. See various indications in his carefully prepared additions in vol. 2 of his "Electrical Papers"; also Clerk Maxwell's trenchant remarks in a reference that has escaped my memory. The scientific interest of the note now revealed lies perhaps in the expression of his conviction that the velocity of propagation of magnetic influence would prove to be small enough to be measurable.

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Holywood,
N. Ireland.
Dec. 1.

Diffraction of Light by Supersonic Waves in Solids

RECENTLY one of us[1] pointed out that the optical diffraction effects by supersonic waves in solids are to be interpreted on the basis of the Raman-Nath[2] theory, taking due cognisance of the photo-elastic effects arising from the strains caused by the sound waves. A refined further development of this idea enables us now to offer an explanation for a curious effect observed by Hiedemann and Hoesch[3]. Their experiments with glasses show two diffraction patterns of different spacings. With crossed Nicols normal and parallel to the sound-wave, only the pattern with the larger spacing is observed. It consists of the first orders only, with the central one missing. With the crossed Nicols at $\pm 45°$ to the sound-wave, only the pattern with the smaller spacing appears, showing many orders, including the central one.

This effect is characteristic for solids. For liquids no diffraction effects appear for crossed Nicols. As Schaefer and Bergmann[4] first pointed out, the existence of two patterns is due to the fact that in solids longitudinal and transversal sound-waves of the same frequency but different wave-lengths can travel simultaneously. Hence the theoretical problem consists in finding the propagation of a light-wave in a medium containing both types of waves.

We can gain an insight into the probable theoretical results by considering first the diffraction effects of either type of waves alone. Since transversal waves travel slower than longitudinal waves, their wave-length λ_T is smaller than λ_L, and the pattern with the larger spacing must be ascribed to the transversal wave. A transversal sound-wave, the directions of oscillation and propagation of which are normal to the light beam, produces a photo-elastic effect characterized by an index ellipse the axes of which are at 45° to the sound-wave. The principle indices of refraction suffer fluctuations μ and $-\mu$ which are equal in magnitude but opposite in phase. If the incident light is polarized parallel to the sound-waves, the two light-components parallel to the axes travel independently and their nth order has components of magnitudes $J_n(2\pi\mu L/\lambda)$ and $J_n(-2\pi\mu L/\lambda)$, where J_n is the Bessel function of nth order, L the width of the supersonic field and λ the wave-length of the incident light. These components are in phase or in opposite phase as n is even or odd. Hence it is easily seen that all even orders, including the central one, have the same polarization as the incident light and are therefore not visible through crossed Nicols. Only the odd orders can appear, in conformity with the observation of Hiedemann and Hoesch. If the crossed Nicols are at 45° to the sound-wave, that is, parallel to an optical axis, the diffraction effect by transversal waves must vanish.

For a longitudinal sound-wave the axes of the index ellipse are normal and parallel to the wave and the index fluctuations μ_1 and μ_2 are in phase but of different magnitude. With crossed Nicols parallel or normal to the sound-wave, the diffraction effects due to the longitudinal wave vanish. If the polarizing Nicol is at 45° to the sound-wave, all diffracted orders are plane polarized, but with a plane of polarization different from that of the incident light. Hence all orders are visible through crossed Nicols, but each order can be made to vanish by rotating the analysing Nicol. In the case of standing sound-waves, the intensity of the various orders passes through a minimum which is different from zero.

These are, of course, preliminary considerations for the development of a more complete theory considering the simultaneous existence of both types of waves. Work along this line has already shown that the diffraction angles φ are generally given by $\sin\varphi = n\lambda/\lambda_L + m\lambda/\lambda_T$, where n and m are integers, but if the light is polarized parallel to the sound-waves, only even m's enter for parallel, and only odd m's enter for crossed Nicols.

N. S. NAGENDRA NATH.
HANS MUELLER.

University,
Cambridge.
Nov. 23.

[1] Mueller, H., *Phys. Rev.*, **52**, 223 (1937).
[2] Raman, C. V., and Nagendra Nath, N. S., *Proc. Ind. Acad. Sci.*, **2**, 406, 413 and **3**, 75, 119, 459 (1936).
[3] Hiedemann, E., and Hoesch, K. H., *Naturwiss.*, **24**, 60 (1936).
[4] Schaefer, Cl., and Bergmann, L., *Naturwiss.*, **22**, 685 (1934) and *Sitzgsber. preuss. Akad. Wiss.*, **14** (1935).

Magnetic Moments of the Proton and the Neutron

IT is well known that the magnetic moment of the proton and the neutron cannot be explained by Dirac's relativistic wave equation. It was first suggested by Wick[1] that the surplus moment of the proton may be explained by Fermi's β-theory, according to which the proton spends a certain fraction of its life in a virtual state as a neutron plus a free positive electron and neutrino. Since the electron has a large magnetic moment, this state will contribute considerably to the magnetic moment of the proton. Since, however, the β-decay constant is exceedingly small in nuclear dimensions, it has not been possible to account for the observed momenta in this way.

A new hope for such an 'exchange theory' of the magnetic moments is perhaps offered by the probable existence of a hitherto unknown type of particle constituting the hard component of cosmic radiation. It has been suggested that they are 'heavy electrons' with a mass somewhere between that of the electron and the proton. Since these particles are certainly not stable, it might be plausible to assume that they can be emitted and absorbed by nuclear particles in a similar way as in the β-decay. We therefore assume that, in suitable circumstances, a proton (or neutron) can emit a positive (or negative) heavy electron, transforming itself into a neutron (or proton). Hence it would follow that heavy electrons have no spin and satisfy Bose statistics. In order to account for the magnetic moment of the proton and neutron, it is necessary to choose an interaction between the heavy particles and the heavy electrons depending on the relative directions between the spin of the proton (neutron) and the angular momentum

of the emitted heavy electron. Such an interaction can easily be found and has the property that a proton (neutron) with spin in the $+z$-direction can only emit a heavy positive (negative) electron with angular momentum $+1\hbar$ about the z-direction transforming itself into a neutron (proton) with spin in the $-z$-direction. Thus angular momentum is conserved.

The details of this 'interaction *Ansatz*' and their bearing on the nuclear forces will be discussed elsewhere. Without reference to the special type of the interaction chosen, it is possible to calculate the *mass of the heavy electron* from the observed data. Let α be the fraction of time which a proton (neutron) spends in a virtual state as a neutron (proton) + heavy electron and let us assume that the proton satisfies—apart from the above interaction—Dirac's equation; and let M be the mass of the proton, m that of the heavy electron. If we measure all magnetic moments in units of the Bohr nuclear magneton, the magnetic moments of the proton μ_P and neutron μ_N will then be

$$\mu_P = 1 - \alpha + \alpha\frac{M}{m},$$

$$\mu_N = -\alpha - \alpha\frac{M}{m}.$$

Hence we obtain

$$\frac{M}{m} = \frac{\mu_P + |\mu_N| - 1}{1 - \mu_P + |\mu_N|}.$$

Inserting the observed values $\mu_P = 2{\cdot}6, \mu_N = -1{\cdot}75$, we obtain $M/m = 22$ or $m = 80$ electron masses.

This value of m depends sensitively on the departure of the value of the magnetic moment of the deuteron $\mu_P - |\mu_N|$ from 1. But the order of magnitude of ~ 100 electron masses will probably be right. This seems to be quite in accord with cosmic ray data.

H. FRÖHLICH.
W. HEITLER.

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University of Bristol.
Nov. 24.

[1] Wick, R. C., *Accad. Lincei*, **21**, 170 (1935). Cf. also Kahn, *Physica*, **3**, 495 (1936).

Orientation Habit of Martensite

FOR many years, metallurgists have believed that martensite, the hardening constituent in iron-carbon alloys, forms along the octahedral {111} planes of austenite. In 1933, Mehl, Barrett, and Smith[1] reported experimental results which they interpreted as verification of this assumption.

Recently, we have succeeded in demonstrating conclusively that martensite in quenched plain high-carbon steels is *not* parallel to the octahedral {111} planes of the austenite lattice; in fact, the martensite plates are parallel to no low-indices plane of austenite. Actually, the poles of planes delineated by martensite midribs deviate about 2° or 3° from {421} of the austenite lattice; thus, they are not far from the mean cementite-plate orientation determined by Mehl, Barrett, and Smith[1]. Our experimental procedure was, briefly, as follows: Specimens containing large (1–3 mm.) austenite grains saturated with carbon at 1130° C. were prepared (by a suitable annealing treatment) and rapidly quenched from that temperature in a solution of 10 per cent caustic soda. The orientations (to within $\frac{1}{4}$°) of the austenite grains were determined by means of the back-reflection Laue X-ray method; and from a microscopic measurement (and pairing) of martensite midribs on two prepared surfaces, the poles of martensite plates were located stereographically with respect to the orientation of the austenite lattice. Poles of twin bands in the austenite grains, located for check purposes, were found to deviate less than $\frac{1}{2}$° from {111} poles located from the X-ray data.

These austenite grains, which at 1130° C. were saturated with carbon, were found to have, after quenching, a perfect lattice structure with no indication of any distortion, and the martensite midribs in these austenite grains could be measured (that is, were parallel) to within $\frac{1}{2}$°. In specimens having carbon contents appreciably less than the above saturation value, the retained austenite grains have a distorted structure, manifested in a symmetrical broadening of the Laue spots on the X-ray patterns. For all carbon contents investigated so far, the martensite orientation habit is essentially the same. Thus, the martensite transformation in iron-carbon alloys, far from producing a simple octahedral pattern in austenite, actually shows an irrationality in orientation habit comparable to that of the "martensitic transformation" in brass[2].

It is expected that when the complete results of this and collateral work now being conducted at our laboratory become available, it should be possible to give a more comprehensive picture of the interrelation of the various 'constituents' in steel than has been presented heretofore.

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ALEXANDER R. TROIANO.

Laboratory of Physical Metallurgy,
Harvard University Graduate School
of Engineering,
Cambridge, Massachusetts.
Nov. 23.

[1] Mehl, Barrett, and Smith, *Trans. Am. Inst. Min. and Met. Eng.*, **105**, 215–258 (1933).
[2] Greninger and Mooradian, *Metals Technology* (*A.I.M.E.*), December 1937.

The Surface Slit Viscosimeter and the Viscosity of Monolayers

PERHAPS the greatest advantages of the surface viscosimeter which makes use of the flow of a film through a rectangular slit are (1) that the theory is relatively simple, and (2) since there are no moving parts, the substrate, usually water, is not set in motion by the apparatus, but only by the film. In a recent letter in NATURE[1], Harkins and Myers show that the flux of the film through a narrow slit varies inversely as the cube (a^3) of the diameter of the slit. Since this neglects the effect due to the viscosity of the substrate, η_0, it seems to be essential to develop the complete theory, and this has been done by one of us (Kirkwood). For a slit of length l, depth h, and width a, the area flux A, is given by

$$A = \frac{8\alpha a^3}{\pi^4}\sum_{n=1,3,5,\ldots}^{\infty} \frac{1}{n^4\left[\eta + \frac{a\eta_0}{\pi n}\coth\frac{\pi n h}{a}\right]} \quad (1)$$

where $\alpha = (f_2 - f_1)/l$ is the pressure gradient in the slit. If h/a is large relative to unity, this may be

represented by a practically adequate approximation as

$$\eta = \frac{\alpha a^2}{12A} - \frac{a\eta_0}{\pi} \qquad (2)$$

The slit viscosimeter is an extremely delicate instrument, when used with small diameters. Expanded films, such as those of oleic, myristic or pentadecylic acid, have very low viscosities, and for their measurement the value of a should be 0·1 mm. or less. For 0·1 mm. the correction term is only − 0·00003 surface poises.

The substrate correction, $-a\eta_0/\pi$, is added to the earlier equation. While the highest viscosity (0·0018 surface poises for arachidic acid) given by Harkins and Myers is essentially correct, the lower values are too large by more than the experimental error. The correction applicable to their slit of negligible depth is *smaller* than the term given above, so to insure accurate results the work is being repeated by the use of a slit which meets the demands of the theory.

In the earlier letter, a ring viscosimeter, which vibrates as a torsion pendulum, was described. In addition, there is now in use a surface ring which rotates at a constant rate, either without or with a guard ring, the latter being used to simplify the theory. While theories may be developed for these instruments for the calculation of the absolute viscosity, the theories are somewhat doubtful, so it seems better to calibrate these instruments by the use of the slit viscosimeter.

WILLIAM D. HARKINS.
JOHN G. KIRKWOOD.

University of Chicago.
Nov. 16.

[1] NATURE, **140**, 465 (1937).

Sorption of Carbon Dioxide by Chlorophyll

THE interaction of chlorophyll with carbon dioxide is of obvious interest in connexion with the problem of photosynthesis. The formation of an addition product of chlorophyll and carbonic acid has been often assumed to be the first stage in the reduction process.

We performed some experiments to see if solid chlorophyll has any affinity for carbon dioxide. The preparation used was crystalline ethyl chlorophyllide ($a+b$ mixture, 0·3 gm. kindly supplied by Prof. A. Stoll of Basle). It was degassed in high vacuum at 70–80° C. and brought into contact with pure carbon dioxide gas under different pressures. A considerable sorbing capacity was found. The sorption is perfectly reversible, and the equilibrium is established in a few seconds. The sorption isothermals for 0° C. and −80° C. were measured out, point by point, in the interval $p = 0$ to 700 mm. They are perfectly reproducible smooth curves, and can be represented by the sorption formula derived previously[1] for the sorption of gases by crystalline lattices ('zeolithic' sorption). The heat of sorption is 2·6 kcal. per mol, and the saturation corresponds to 2 mols carbon dioxide per mol of ethyl chlorophyllide. The maximum sorption actually observed (−80° C., $p = 600$ mm.), was 1·1 mols/mol; at 0° and $p = \frac{1}{4}$ mm. (partial pressure of carbon dioxide in the air), about 1 ethyl chlorophyllide molecule in 15,000 is carrying a carbon dioxide molecule.

The relation of these results to the experiments of Willstätter and Stoll[2] on sorption of carbon dioxide by colloidal chlorophyll solutions will be discussed elsewhere, together with the details of our experiments.

I wish to thank Mr. K. W. Jones for his help in carrying out the experiments.

E. RABINOWITCH.

Sir William Ramsay Laboratories of
Inorganic and Physical Chemistry,
University College,
London.
Dec. 5.

[1] Rabinowitch, E., and Wood, W. C., *Trans. Faraday Soc.*, **32**, 947 (1936). In formula (4) and (6) of this paper, $R^{2/3}$ is a misprint for $R^{1/3}$.

[2] Willstätter, R., and Stoll, A., "Untersuchungen über die Assimilation der Kohlensäure", pp. 227–314 (Berlin, 1918).

Mechanism of the Biological Synthesis of Acetylcholine

THE well-known work of Prof. O. Loewi and of Sir Henry Dale and their collaborators has established the widespread function of acetylcholine as a chemical transmitter of nervous action. It has further been established that there exists in the animal organism a specific enzyme, choline-esterase, which effects the rapid destruction of this ester. Interest, therefore, now centres round the mechanism whereby acetylcholine is produced in the body.

Making the assumption that the synthesis in question occurs in nervous tissue, we recently[1] succeeded in demonstrating conclusively that acetylcholine is produced in minced brain from the ox when this tissue is incubated under certain specified conditions. We further obtained some evidence which suggested that acetoacetic acid or one of its derivatives could act as a precursor of the acetyl moiety of the acetylcholine molecule, but the magnitude of the increase in the yield of acetylcholine produced by the addition of sodium acetoacetate to the incubating material was not sufficiently great to justify us in concluding with certainty that this substance acted as an immediate precursor.

Further progress has now been made in the elucidation of this problem. An examination of different portions of the brain by the technique previously described has shown that the synthesis of acetylcholine *in vitro* occurs to a preponderating extent, although not exclusively, in the grey matter, and that rather more is produced by the basal ganglia than by the grey cortical tissue. In view of this result and of the ease with which the basal ganglia can be removed from the remainder of the brain, we have now used this material in place of whole brain for ascertaining the influence of sodium acetoacetate on the synthesis of acetylcholine. The effect of the addition to this tissue has proved to be much greater than was previously observed with whole brain. In experiments which have been repeatedly carried out, the addition of 20 mgm. of sodium acetoacetate to 10 gm. of basal ganglia has increased the yield of acetylcholine, as determined by its action on the dorsal muscle of the leech, by 100 per cent. Further, although smaller, increases are produced by the addition of 10 mgm. of choline chloride.

These results appear to us to demonstrate that acetylcholine is synthesized biologically from choline and acetoacetic acid essentially according to the hypothetical scheme which we previously outlined, although they do not exclude the possibility that

minor details of the process still require elucidation. The synthesis is presumably of an enzymic nature, and we are now commencing experiments designed to separate the enzyme concerned from the nervous tissue.

We hope later to give a more detailed account of our work and also to discuss some of the implications of our findings.

EDGAR STEDMAN.
ELLEN STEDMAN.

Department of Medical Chemistry,
University, Edinburgh.
Nov. 26.

[1] *Biochem. J.*, **31**, 817 (1937).

A Clay Adjunct to Potato Dietary

IN the course of an expedition to Lake Titicaca, South America, financed by the Percy Slade Trustees in which one of us (H. P. M.) took part, an interesting observation was made in regard to the diet of the Quetchua Indians on the Capachica Peninsula near Puno. These people are almost certainly descendants of the Incas and at the present time live very primitively. They exist largely on a vegetable diet of which potatoes form an important part. Immediately before being eaten, the potatoes are dipped into an aqueous suspension of clay, a procedure which is said to prevent 'souring of the stomach'.

We have examined this clay and found it to consist of kaolin containing a trace of organic material, possibly coumarin, and presumably a decomposition product of the grass from underneath which the clay is dug. The local name for the clay is Chacco, and the Indians distinguish between good and bad qualities. This dietetic procedure is universal among the Indians of the Puno district, and is probably of very ancient origin.

Such a practice by a primitive people would appear rather remarkable in view of the comparatively recent introduction[1] of kaolin into modern medicine as a protective agent for the gastric and intestinal mucosa and as a remedy for bacterial infections of the gut.

ALEXANDER LAWSON.
H. P. MOON.

University College,
Southampton.
Dec. 14.

[1] "British Pharmaceutical Codex", 1923.

Points from Foregoing Letters

A description and diagrams submitted by Prof. A. H. R. Buller show the thread-like flexuous hyphæ of *Puccinia graminis* (which causes the black stem rust in wheat) in the process of fusion with the gelatinous spores of opposite sex (produced in the pycnidia).

Prof. F. J. Lewis finds that the outer surfaces of the mesophyll cells in the leaf, which are unwettable by water but wettable by hydrocarbons, show strong adsorption of protein sensitizing dyes such as janus green. Within certain *p*H limits, protein dispersing fatty acids such as sodium taurocholate render the surfaces readily wettable with water. The author suggests that they are protein in nature and of molecular thickness.

Photographs showing the effect of small amounts of the 'growth-hormone', 1-naphthylacetic acid on 'nasturtiums' are submitted by N. H. Grace. Optimum results were obtained with a solution containing one part in ten millions. Green tops of lettuce plants increased threefold on addition of 150 mgm. per acre.

Experiments made by Prof. K. Wodzicki and his collaborators on the homing of storks have shown that these birds can return to their nests from distances of no less than 2,260 km. in a straight line. It is concluded that there exists a special sense of orientation in some species of birds.

The term 'gynæcogenic' is suggested by Dr. A. S. Parkes as of more general application than 'œstrogenic' in connexion with substances which induce female characteristics, for example, in the plumage of birds. He also recommends 'ambisexual' in place of 'bisexual' and 'gonadotrophic' instead of 'gonadotropic'.

The curious diffraction effects due to supersonic waves in glasses, as observed by Hiedemann and Hoesch, are explained by N. S. Nagendra Nath and Prof. Hans Mueller on the basis of the Raman-Nath theory by taking into account the phase relations of the index variations. New results are predicted concerning the polarization of the light diffracted by the longitudinal sound waves and the existence of new diffraction lines.

In order to explain the magnetic moment of the proton and of the neutron, Dr. H. Fröhlich and Dr. W. Heitler postulate the existence of a hitherto unknown particle with a mass somewhere between that of the electron and the proton. From theoretical considerations they calculate for the new particle a mass about eighty times that of the electron. Such particles, the authors state, may constitute the hard component of cosmic radiation.

A. B. Greninger and A. R. Troiano find that in quenched plain high-carbon steels the hardening constituent, martensite, is not oriented parallel to the octahedral planes of the austenite lattice but more nearly parallel to the direction of the mean cementite-plate orientation.

A formula for determining the viscosity of surface films (monolayers) flowing through a narrow slit, developed by J. C. Kirkwood, is submitted by Prof. W. D. Harkins and Prof. J. G. Kirkwood, who indicate the conditions which have to be satisfied.

Solid chlorophyll (crystalline ethyl chlorophyllide) is found by Dr. E. Rabinowitch to have a maximum sorption for carbon dioxide of 1·1 mols/mol at −80° C., under a pressure of 600 mm. At 0° C. and usual concentration of carbon dioxide in the air ($\frac{1}{4}$ mm. partial pressure) the author found about one molecule of carbon dioxide to 15,000 molecules of ethyl chlorophyllide.

Dr. and Mrs. Stedman find that the formation of acetylcholine occurs mainly in the grey matter and the basal ganglia of the brain. They consider that this substance is formed biologically from acetoacetic acid and choline, since the addition of sodium acetoacetate to the basal ganglia doubles the yield of acetylcholine, while a further, although smaller, increase results from the addition of choline.

Research Items

Archaic Culture of the Northern Andes

MM. A. Métraux and H. Lehmann figure and describe (*J. Soc. des Américanistes*, N.S. 29, 1) archaic objects sculptured in stone which were acquired in the course of an expedition to the plateau lands of Bolivia in 1931. Some time was spent at Oruro, where they were advised of the existence of a collection of these objects. They traced them to the village of Belén in the province of Cercado, forty-five kilometres from Oruro. Here similar examples were found sparsely scattered among miscellaneous rubbish, derived from buildings, in a mound in the centre of the village. The mound was about fifteen metres high and about thirty metres long. Other sculptures were found in the walls of adjacent enclosures and buildings, as well as a number of inscribed plaques, some built into the structure of the church. Excavation of the mound was impossible. Much potsherd material was scattered about the mound, but of modern origin. The objects collected, archaic in style, consisted of a number of heads of Felidæ of a varying degree of realism, heads with conventional representations of the human features, a llama, in which the natural form of the stone is merely elaborated, and a number of stones and plaques with geometrical ornament. There is also a figure of a demon. A small number of such archaic sculptures had been recorded previously; but nothing was known of their origin and affinities, beyond that they showed no relation to any known form of Andine prehistoric art. They were evidently intended for affixing to the walls of a building, and with this as a clue a relation with the earliest phase of the Tiahuanaco culture is established. It is therefore concluded on a basis of comparative study that these sculptures represent the most southerly extension of an archaic north Andean culture, and the most archaic phase of Andean sculpture and art.

Economics of Retail Milk Distribution

RETAIL milk distribution has been the object of much criticism on the grounds that it is unnecessarily costly, that the number of retailers is excessive and that wasteful expenditure is involved in competitive advertising and canvassing. Competition, moreover, compels distributors to provide expensive facilities, such as deliveries in half-pint bottles, two deliveries a day and deliveries at special times. Various aspects of the problem are discussed in a useful report by the Food Council on its inquiry into "Costs and Profits of Retail Milk Distribution in Great Britain" (H.M. Stationery Office. 9*d*.). This report examines variations in costs of distribution, profit margins and the possibilities of effecting savings through a more rational organization of the trade. It emphasizes the fact that the overlapping which is inherent in the retail milk distributive industry is responsible for much duplication of effort and in consequence for much expenditure that is uneconomic. Costs are shown to vary considerably owing to differences in 'rounds', dairy costs, advertising and other circumstances and they range, for example, in the case of pasteurized milk from 5¾*d*. to 9½*d*. per gallon among eight provincial co-operative societies and from 9¾*d*. to 12½*d*. per gallon among seven proprietary businesses in the provinces. The evidence, it is stated, does not suggest that, taking the trade as a whole, profits are substantially in excess of what is reasonable, though a certain proportion of undertakings are making a liberal rate of profit on turnover. It is concluded that to reduce working costs and thus to lower the retail price of milk, it is essential to reduce the number of distributors and to rearrange trade as between one distributor and another, including a concentration of processing and distributing depots.

A Specific Phosphatase in the Nervous System

AN interesting observation recently made by J. Reis (*Enzymologia*, 2, 110; 1937) indicates that the nervous system has a marked ability to break down adenylic acid and its deaminated product inosinic acid. Under conditions where the α- and β-phosphoric esters of glycerol were hydrolysed to the extent of 1 per cent or less, an extract of the white matter of brain hydrolysed inosinic and adenylic acids to the extent of about 40 per cent. This phosphatase is termed 5-nucleotidase, and its action appears to be specific to adenylic and inosinic acids. It occurs both in the white and in the grey matter of brain, in the spinal cord, in peripheral nerve and, to the greatest extent, in retina. A kidney extract proved to be very much less active than an extract of nervous tissue. Magnesium ions have only a small activating action on the enzyme, the optimal activity of which lies between *p*H 7·0 and 7·5. It is probable that so active an enzyme will play an important part in the metabolism of the nervous system.

Adaptive and Constitutive Enzymes

IT is now well known that the formation of enzymes of bacteria may depend greatly on nutritional conditions. A study of these conditions has given rise to the view that bacterial enzymes may be classified as adaptive when they are formed as a response to the presence in the nutritional medium of the specific substrates upon which they act, or as constitutive when they are formed independently of the composition of the nutritional medium. Experiments by J. H. Quastel (*Enzymologia*, 2, 37; 1937) make it clear that this classification may need modification. Working with suspensions of *M. Lysodeikticus*, it was shown that the urease content of the organism increased, not when urea was present in the nutritional medium, but when glucose was present. On the other hand, the catalase content of the organism decreased when glucose was present in the nutritional medium. It appears, therefore, that the enzymes of the cell may be considerably affected by substances, other than their specific substrates, in the nutritional medium. It is pointed out that the enzyme content at any time in the cell must be a function of the rate of its formation and of the rate of its destruction in the cell, and nutritional conditions may affect these rates differently.

Classification of Marsupials

THE division of the Marsupialia into Polyprotodontia and Diprotodontia was originally suggested by Owen and has been widely followed by zoologists. Another classification, based upon the presence or absence of syndactyly, that is, the union of the second and third digits of the foot save for their

claws, has been put forward by Wood Jones. Taking both the dental arrangement and syndactyly into account two equivocal families are discovered, the Peramelidæ and the Coenolestidæ. A. A. Abbie (*J. Anat.*, July 1937) has shown that it is possible to use another criterion, and that is the presence or absence of a fasciculus aberrans, an additional, easily recognizable tract in the anterior commissure of the brain. It is found in Diprotodontia but not in Polyprotodontia, and as it is absent in the two equivocal families they are both referable to the Polyprotodontia. The syndactyly of *Perameles* and diprotodontism of *Coenolestes* are regarded as the results of convergence

Goose Hybrids

Two crosses which do not seem to have been noted previously have been described by Einar Lönnberg (*Arkiv f. Zoologi*, 29 B, No. 8; 1937). One is a hybrid between two species belonging to different genera *Branta canadensis* × *Anser anser*; the other between species grouped in different subgenera, *Anser* (*Eulabeia*) *indicus* male × *Anser albifrous gambelli* female. An account is given of the plumage and colour characteristics of the hybrids. The hybrids were raised at Bokenäs on the coast of Kalmar Sound, where the grey lag-geese stock was raised from eggs imported from Sweden and Denmark. The grey lags were allowed to fly freely and some of them migrated and later returned to the place of hatching and upbringing. That the migration journeys were quite extensive was shown by the shooting of one of the marked migrants on the Lower Guadalquivir in Spain, while others were shot in France, Germany and Denmark.

A Land Nemertean in Britain

AN unusual record has been made of the occurrence of a land nemertean (*Geonemertes dendyi*) living in open-air conditions near Swansea, the first known case of the establishment of a land nemertean in the temperate climate of Europe (*Proc. Roy. Soc. Edinburgh*, 57, 379). A. R. Waterston and H. E. Quick describe the external and internal characters of the species, and record the habits they have observed in specimens at large and in captivity. In Nature eggs were laid in March, and in captivity in October, November and April, and hatching took place after about three weeks. The localities inhabited were all damp places, and the worms were most numerous where there seemed to be least interference by man. The species now found in Wales was originally described by Dakin from West Australia, but since then it has turned up in glass-houses in the Botanic Gardens at Breslau in Germany. Like others of its kind, it has suffered unintentional transportation with vegetation or soil carried by man.

Neuropteroid Insects from Formosa

MR. N. BANKS, of the Harvard University Zoological Museum, has recently described a number of new species and identifies others belonging to the orders Psocoptera, Plecoptera and Neuroptera (*Philippine J. Sci.*, 62, 255–291; 1937). It is apparently at once noticeable with these insects, as with others, that the Formosan fauna shows great affinity with the species found on the Asiatic mainland, particularly the highlands. In general the species, and many of the genera, are different from those occurring in the Philippines. The numerous Panorpidæ, the large Sialids, the Raphidias as well as most of the Plecoptera are wholly foreign to the Philippines. These insects show much more affinity with those of Japan, yet Formosa is about three times the distance from Japan that it is from the Philippines. Most of the genera and many of the species are the same as those which occur in Japan.

The Genus *Bathychordæus*

THE genus *Bathychordæus* is one of the most remarkable among the Appendicularia, and hitherto our knowledge of the genus has been limited to the accounts of four specimens from the deep water of the South Atlantic and the Indian Oceans. The fortunate capture of two specimens at Bermuda in a very good state of preservation has enabled W. Garstang (*J. Linn. Soc.*, Zool., 1937) to add considerably to that knowledge. There seems little doubt that these specimens are congeneric with those previously recorded, but they are regarded as belonging to a new species, for which the name *B. styguis* is proposed. They have no Eisen's oikoplasts, no oral glands and no sub-chordal cells in the tail. They do possess Fol's oikoplasts, contrary to what was previously believed. The totality of the structure leads to the suggestion that the type is somewhat archaic, and while showing some affinities with the *Oikopleura fusiformis* group, also shows others with the *Fritillaria* group.

Control of White Plaster Mould

THE fungus *Oospora fimicola* often makes its appearance upon the surface of mushroom beds, where it excludes the more welcome fungus crop. Large white patches are formed, and give to the invader its name of white plaster mould. Messrs. W. F. Bewley, J. Harnett and P. H. Williams have investigated methods for control of this unwanted competitor (*Gard. Chron.*, Aug., 1937). It has been shown that *O. fimicola* does not grow when the acidity of the medium is below *p*H 4·6, and control of its activities has been obtained by removal of infected casing soil, and its replacement by peat saturated with dilute acetic acid. The question as to whether peat alone might be sufficiently acid to control the fungus arises from a consideration of the paper, for many samples of peat have an acidity of *p*H 4·5 or less.

Atomic Weight of Lutecium

HÖNIGSCHMID (*Naturwiss.*, 25, 748; 1937) has carried out a redetermination of the atomic weight of lutecium by analysing lutecium chloride and finding the ratios $LuCl_3$: 3Ag : 3AgCl. The sample of the chloride used was found by X-ray spectrographic methods to contain 1·18 per cent of ytterbium, but no other rare earths in measurable quantity. Allowing for this impurity, the atomic weight of lutecium was found to be 174·98. A difference between this value and that obtained by Aston (174·91) by the mass-spectrograph was expected owing to the announcement by Gollnow (*Z. Phys.*, 103, 443; 1936) of the existence of a new isotope of mass-number either 173 or 177 in lutecium. The amount of this isotope, according to more recent work by Gollnow, might be as great as 2·5 per cent. Hönigschmid points out that if the isotope has mass-number 177 and is present to the extent of 2·5 per cent, the mass-spectrographic value for the atomic weight of lutecium becomes 174·96, which is close to the chemical value now reported.

Isotopic Composition of Ordinary and Uranium-Lead

THE isotopic composition of uranium-lead is of importance in the determination of the mass numbers of the radioactive elements of the actinium series, the atomic weight of protactinium, the half-life period of actinium-uranium, and the age of the earth. A new determination of this isotopic composition is reported by J. Mattauch and V. Hauk (*Naturwiss.*, 25, 763; 1937). Lead chloride prepared from Katanga curite was used for the investigation, and the percentages of isotopes of mass-numbers 204, 206, 207 and 208 were 1·1$_5$, 24·5$_5$, 21·3$_5$ and 52·9$_5$, respectively. These values are a little different from those obtained by Aston. Assuming a packing-fraction of 1×10^{-4}, and using the correction factors of Smythe, and Mecke and Childs for the ratios $^{16}O/^{18}O$, and $^{17}O/^{18}O$, respectively, the value for the atomic weight of uranium-lead on the chemical scale (O = 16) is 207·21. This is identical with the value given in the International Atomic Weight Table for 1937. The isotopic composition of ordinary lead was found to be 95·1 per cent of ^{208}Pb, and 4·9 per cent of ^{207}Pb, giving an atomic weight of 206·01 (O = 16).

Illumination of Buildings

FROM the Engineering Experiment Station of the University of Illinois there have recently been issued two papers by Prof. John O. Kraehenbuehl, giving the results of investigations in lighting and illumination. "Problems in Building Illumination" (Circular No. 29) treats of the general principles underlying the necessity for good lighting and the problems met with in obtaining it. The author first discusses the factors involved in 'seeing', a term used to indicate the fundamental relationships between vision and lighting. The human eye was adapted by evolution for long-distance vision and high illumination, but now works under low illumination at close range. Ordinary conditions are 18 in. distance, 3–10 foot-candles and usually considerable glare, and the effect is strain on the muscles of convergence and of accommodation, the symptoms of which are local—such as smarting and watering of the eyes—and reflex—such as headaches and indigestion. From these conditions, the author proceeds to consider illumination requirements and the systems of lighting in use and, in order to show the relationship between the theoretical and the practical aspects of the problem, makes an analysis of several specific examples. In "An Investigation of Student Study Lighting" (Circular No. 28) he gives an account of a survey made of a large number of students' studies. A supplementary investigation of the different types of lighting equipment used in these was made in the Electrical Engineering Laboratory, where a specially equipped room was provided. The methods and material in use were found in most cases to be conducive to eye irritation and unfavourable to concentrated thought. The results, which should be applicable to analogous cases, showed that the most suitable arrangement was a standard indirect lighting fixture placed 30 in. from the ceiling and above the centre of the right-hand edge of the table. Equipped with a 500-watt lamp, this furnished the correct amount of illumination free from glare or shadow on the work surface, and gave, at the same time, the proper illumination to the surrounding walls, this latter being an essential condition for proper eye relaxation.

Babylonian Algebra

IT is now well known that some Babylonian cuneiform texts contain quadratic equations with correct solutions. According to S. Gandz, the word *algebra* is not really Arabic, as generally supposed, but an Arabic form of the Babylonian term *gabrumaharu*, meaning to confront, compare, or set up an equation. Mr. Gandz (*Scientia*, 52, 249; 1937) gives further details of Babylonian methods. They did not deal with quadratic equations directly, but approached them by problems concerning rectangles. The first type of problem sought to determine the sides when their sum was known and also the area. A second type replaced the sum by the difference. There were four other types, in which were given the diagonal and the sum or difference of the sides, or one side and the sum or difference of the diagonal and the other side. Mr. Gandz points out that Euclid and Diophantus were influenced by this Babylonian work, and four of Euclid's problems were merely the geometrical form of four of these types. After a time, it was discovered that the six traditional Babylonian types were not exhaustive. Quadratic equations with two positive roots became known, but they were regarded as absurdities, since they gave two values for one and the same quantity. All kinds of devices were employed to avoid them and to keep to the traditional problems of the rectangle, where this difficulty did not arise. It was the great merit of the Arabic School, who taught Europe algebra by the famous treatise of Muhammad ibn Musa al-Khuwarizmi (*c.* 820), that it had the courage to throw over the traditional methods and to replace the six Babylonian types, and all the ingenious devices necessary to employ them, by the three simple and standardized Arabic types. A later age, by the recognition of negative numbers, was able to reduce these to one.

Studies of the Remote Nebulæ

INVESTIGATIONS into the distribution of the distant nebulæ, which are beyond our galactic system, have shown from 'small-scale' sampling that there is a tendency for those nebulæ towards clustering. This observed tendency is believed to be intrinsic; there appears to be, in fact, an unbroken sequence from double galaxies and multiple galaxies to the metagalactic clusters and the superclusters. The "Whirlpool" nebula (Messier 51) is an example of a double system; the great Andromeda nebula with its two satellites (*M.* 32 and *N.G.C.* 205) is an example of a triple system. Such systems provide unique data for studying the relative dimensions of the nebulæ at various stages of the sequence classification, and in certain cases may provide the data for a statistical determination of the relative masses of these star systems. With this end in view, Mr. Erik Holmberg, in *Annals of the Observatory of Lund*, No. 6, has published a catalogue of 827 double and multiple systems, of which only a very small proportion are believed to be merely optical double or multiple systems. The material for the catalogue has come from the author's examination of the important collection of photographs taken by the late Dr. Max Wolf and his successors at the Heidelberg Observatory, Königstuhl. In a preface to the catalogue, Mr. Holmberg discusses some general problems relating to the extra-galactic nebulæ (termed by the late Dr. Swedish astronomers "anagalactic" nebulæ), as well as describing his procedure in dealing statistically with his data obtained from the Heidelberg plates.

Early Stone Age Cultures of the Great Salt Lake Region, Utah

NO traces of the Folsom culture, the earliest known Stone Age culture of North America, have been found as yet west of the Rocky Mountains. It has been suggested that climatic conditions on the eastern side of the range in early times, possibly so early as the late phases of the Ice Age, were more favourable to human occupation; but the discovery of a primitive culture in caves of the Great Salt Lake region of Utah demonstrates the existence of early man west of the Rockies at a period for which the geological evidence would warrant a very considerable antiquity, possibly in comparative terms not far removed from the close of the Ice Age.

The evidence for this primitive culture is derived from the investigation of caves above the shores of the Great Salt Lake by a joint expedition of the University of Utah and the Bureau of American Ethnology in 1930 and 1931, upon which a report by Julian H. Steward, field director, has been published recently*.

The largest group of caves investigated is situated on Promontory Point on the northern shores of the Great Salt Lake. Another cave at Black Rock on the southern shore was also examined. These caves were once submerged by Lake Bonneville, which at its greatest depth, during the last phase of the Ice Age, stood at a level of one thousand feet above the present level of the Great Salt Lake. A rapid fall in level from the shore-line of this period left its first well-defined terrace, Provo, at no less than three hundred and seventy-five feet below. Further desiccation left only one well-marked terrace, Stansbury, halfway between Provo and the Great Salt Lake, at a point three hundred feet above the latter.

It is with this later terrace, Stansbury, that the earliest of the cultures discovered in the caves is brought into relation. On the assumption that the high-level shore-line dates from the close of the maximum of the final Pleistocene glacial period at about 25,000 years ago, and the Provo terrace from 20,000 years, the Stansbury terrace is assigned a provisional and approximate dating of 10,000 years.

Several caves on the northern shore were examined by members of the expedition, but two only were excavated, and that in part. Of these two, No. 1 yielded artefacts belonging to a single culture of a relatively recent period—1000 A.D. or later. This culture is new and is to be designated "the Promontory culture".

Cave No. 2 is situated much closer than No. 1 to the Great Salt Lake, and in 1931 was sixty-six feet only above water-level. Charcoal and split bones resting on the bedded gravels indicate that it was occupied by man, when the recession of waters first left it habitable, at a date which its position would indicate to have been somewhere between one thousand and five thousand years B.C. It is possible, therefore, that the earliest occupation of the cave may have been contemporary with the Basket-maker I period. The objects of flint and bone found, however, cannot be equated to any known culture; but the paucity of specimens and the limited variety of artefacts make it difficult to define the culture, which at best is impoverished.

The Black Rock cave on the southern shore is 364 ft. above lake-level and 60 ft. above the Stansbury terrace. It must therefore have been habitable some ten to fifteen thousand years ago. No interval appears between the lacustrine gravels and the culture-bearing strata, so that it may be assumed that it was occupied soon after the waters had receded. Evidence of human occupation in the form of charcoal is, in fact, mingled with the gravels. Three more or less distinct periods are represented. The earliest culture, which is associated with an infant burial, lay in the lowest two feet of refuse. Its most significant feature is a complete absence of dart points of quartzite, which are common at higher levels, and the use in their stead of a dart point so minute as to resemble modern arrow points. Other artefacts include knives, scrapers and bone-splinter awls. There is nothing specific to link this cave culture with Signal Butte, Nebraska, Lindenmeier Folsom or Clovis. The greater part of the deposits contains a single culture, the 'Black Rock culture', of which the most conspicuous feature is a distinctive style of corner notched projectile point of grey or reddish quartzite. The leaf-like flint knife appears to be shared by this and the overlying Promontory culture, which constitutes the third distinct element found in this cave.

The paucity of artefacts from the earliest of the cave cultures makes it difficult to attempt, even tentatively, to reconstruct anything like a cultural sequence. Two negative points are to be noted. No single artefact is associated with post-Caucasian objects, and there is little, if any, suggestion of the Basket-maker or Pueblo cultures. Nor is there any great similarity between the Black Rock culture and the early culture of Promontory 2, despite the reasonable assurance that the two were contemporaneous.

It may be stated with certainty that the latest occupants of these caves all belonged to the stage of the Promontory culture. This culture is characterized by the self- and the sinew-backed bow, the reed arrow with hardwood foreshaft, the longitudinally grooved arrow-polisher, "fingernail" and rim-decorated pottery, cedarwood pottery-rests, three- and four-piece mocassins, single rod or rod-and-bundle coiled basketry, triangular flint knives set in wooden handles, and incised slate slabs. It possesses a curious combination of traits of both northern and southern origin; and it is quite distinct from modern Shoshoni, though it may be a form of early Shoshonean. Possibly it is a relic of an Athapascan-speaking people from the north in the course of its migration southward.

Prior to this Promontory culture in the Black Rock cave come the people of the so-called Black Rock culture, characterized most typically by the quartzite dart point, which may or may not be contemporary with Basket-maker and Pueblo, and of uncertain correlation with the early culture of Promontory Cave 2.

The oldest culture of all, preceding the Black Rock culture in the Black Rock cave, has yielded little to characterize it, though its high antiquity appears to be beyond question.

* Ancient Caves of the Great Salt Lake Region. By Julian H. Steward. Smithsonian Institution: Bureau of American Ethnology, Bull., 116 (1937).

Effects of Impulse Voltages on Transformer Windings

IN a paper by Dr. T. E. Allibone, D. B. Mackenzie and F. R. Perry (*J. Inst. Elec. Eng.*, **80**, 118; 1937), the results obtained in a very thorough research on the effects of impulse voltages are given.

To understand what is meant by 'impulse voltage' we have to consider the experiments that have been made during the past seventy years. In 1860 Lord Kelvin wrote a paper describing researches that had been made in his laboratory on the voltage required to produce a spark between spherical electrodes. He used primary batteries in series, and obtained some evidence that the spark occurred when the maximum stress between the electrodes attained a definite value depending on the barometric pressure. If higher voltages had been obtainable, he would have found that except when the electrodes were close together and when they were so far apart that brush discharges appeared on them, there was a certain stress at which the discharge occurred. This is definitely proved by the results obtained by several experimenters some fifty years ago. Knowing, therefore, how to compute the sparking voltages between the electrodes in air in certain cases, attempts were made by electrical engineers to determine experimentally the electric stresses that would produce sparking voltages in materials like glass, ebonite, porcelain and even in non-homogeneous substances like the insulating wrappings of cables. Owing to the very high voltages required, alternating current pressures obtained from a transformer were used. This made a very large high-tension laboratory necessary and greatly increased the cost of research at high pressures.

Instead of using a very high pressure transformer, experimenters sometimes employed batteries of condensers. If there were ten such batteries and they were charged to a potential V in parallel, then in series they would give a potential difference of 10 V. But as Kelvin had shown in 1853, this discharge might be oscillatory, obtaining a maximum voltage which is generally taken to measure the maximum stress and then trailing off in a series of smaller oscillations. The effect of the rush of this oscillating quantity of electricity is sometimes deleterious to the transformer windings. As Duddell pointed out many years ago, when a transformer broke down after a rush of electricity through it, the place of breakdown was generally in the windings first subjected to the effects of the rush. Apart from testing, this problem is of vital importance in power transmission lines where we often have inductance and capacity in series, and a neighbouring lightning stroke or a short circuit may start a travelling 'impulse voltage'.

Messrs. Allibone, Mackenzie and Perry have analysed the effects of the applications of impulse voltages of varied wave shapes to transformers. They have considered both single and multiple 'transients'. They have also experimented on model transformers of different winding characteristics and on both single-phase and three-phase transformers. The constants of these transformers must be known as they determine the voltage distribution within the windings due to the impact of a surge. They have been calculated and measured, and the effect of altering them has been examined. The agreement obtained between theory and experiment is good. The transference of surges from one winding to another is considered. They also discuss the testing of transformers with impulse voltages.

In Germany and Switzerland, surge voltages have been used for transformer testing for several years, and this has improved the quality of the transformers. Recently, test schedules have been suggested both in the United States and in Great Britain with the same object in view. The authors conclude that a knowledge of the behaviour of transients in transformer windings is essential if the most efficient use is to be made of the insulation employed. The problem is made more complex owing to the wide diversity of connexions possible between the windings and by the influence which externally connected circuits may have on the transient within the winding. At the same time, as the designer makes research on the impulse voltages within the windings, he must ascertain the behaviour of the insulation employed under a variety of applied impulses, so that by combining the knowledge of voltage distribution with a knowledge of the electric strength of materials, a forecast of the breakdown voltage of the transformer under test conditions can be obtained.

Alloys of Magnesium

MAGNESIUM, the sixth most abundant element in the world, was first made commercially in 1857, and in the last twenty years its price has dropped from 25*s.* to 1*s.* 3*d.* a pound. The recent demand for lightness in construction has led to a great deal of research being undertaken in many countries on the possibility of using magnesium alloys in place of the heavier aluminium alloys as engineering materials, and the results obtained are scattered in many scientific and technical journals. The Metallurgy Research Board of the Department of Scientific and Industrial Research arranged for the results to be summarized by Dr. J. L. Haughton and W. E. Prytherch*.

One of the great limitations to the use of magnesium alloys at the present time is that they tend to corrode very readily in certain types of water, although the corrosion is not always so severe as was originally believed. Much work has been done to find some metal which would notably reduce this trouble, and 0·5–2·5 per cent manganese has an

* Department of Scientific and Industrial Research. "Magnesium and its Alloys". By Dr. J. L. Haughton and W. E. Prytherch. Pp. viii+100+5 plates. (London: H.M. Stationery Office, 1937.) 2*s.* 6*d.* net.

appreciable influence in this direction. Failing further progress in this field, magnesium alloys will probably have to be protected against severe corrosive conditions by paints applied over some chemically produced film, without which paints will not adhere satisfactorily. Special reference is made to the selenium and to the chromate treatment for the production of protective films as a basis for painting, and it is pointed out that the choice of paint to put on the films is important, as many pigments suitable for iron and steel actually stimulate corrosion on magnesium alloys. Reference is also made to the corrosive action of 'leaded' motor and aviation fuels on magnesium cylinders. It is stated that work at the Chemical Research Laboratory has shown that the addition of 1 per cent of quinoline to the fuel inhibits this action and exerts no harmful effect in its anti-knock properties.

Owing to the ease with which molten magnesium and its alloys combine with oxygen, special methods have to be employed for melting and casting. With the methods described in the monograph, however, it is stated that there is no difficulty in producing castings in magnesium alloys either in sand or permanent moulds.

The monograph summarizes the mechanical properties at room temperatures of the magnesium alloys at present used in industry. These are almost entirely confined to alloys with aluminium and zinc, often containing a small amount of manganese introduced to improve the corrosion-resisting properties. With alloys containing 8 per cent or more of aluminium, it is usually possible to produce increased hardness and a general improvement in properties by suitable heat treatment. This takes the form of exposure to a temperature of 420° C. for a few hours, sometimes followed by tempering for 4–7 days at about 150° C. Increased ductility can be produced by adding cadmium, and reference is made to an alloy consisting of aluminium, silver, manganese and calcium, which has been found suitable for use in stressed parts at room temperature.

A number of possible uses of magnesium alloys involve the exposure of the metal to elevated temperatures, and for this reason their mechanical properties when hot become important. The results of tests up to 300° C. are given for various alloys. Silver, it has been found, increases the ultimate strength of magnesium up to 290° C. but its effect when used alone is not so marked as that of aluminium. Recently cerium has been added, which is stated to have a pronounced effect in increasing the strength of magnesium at elevated temperatures. Even small quantities, of the order of 1 per cent, have a remarkable effect in increasing the hardness at 300° C. The addition of a small amount of calcium to the cerium-magnesium alloys is beneficial in preventing oxidation during melting and heat treatment as well as in improving the age-hardening properties. The increased hardness due to heat treatment is, however, relatively small, even when calcium is present.

A harder alloy can be produced by adding nickel to the cerium-magnesium alloys, but such alloys were found to be very liable to corrosion. This can be reduced slightly by replacing nickel by cobalt and manganese.

The final chapter of the monograph contains reproductions of all known constitution-temperature diagrams for the alloys of magnesium in the form considered by the authors to be most nearly correct.

F. C. T.

Conditions in the Special Areas of Great Britain

SIR GEORGE GILLETT'S admirable first report as Commissioner for the Special Areas of England and Wales, covering the year ended September 30, 1937, shows no departure from the example of frankness and independence of judgment that was set by Sir Malcolm Stewart. The report is indeed in striking contrast to the evidence tendered by the Board of Trade to the Royal Commission on the Geographical Distribution of the Industrial Population. Like Sir Malcolm Stewart, Sir George Gillett stoutly upholds the principle that the State should control the location of industry, asserting that the introduction of tariffs and quotas has enhanced the Government's responsibility in this matter, and that social and strategic as well as economic causes are driving the Government to abandon the old *laissez-faire* attitude. The recommendations in the recent report of the Import Duties Advisory Committee on the present position and future development of the iron and steel industry, no less than the appointment of the Royal Commission, illustrate this tendency.

The first recommendation is that the conclusions of the British Iron and Steel Federation in regard to all schemes of development of the industry should, whether favourable or not, be reported to an independent body looking to the general public interest. This independent body is to be the Import Duties Advisory Committee itself, and Sir George Gillett points out that this recognition that matters which concern the welfare of thousands of our fellow citizens are properly to be considered in relation to their social and broad economic consequences, as well as in relation to the profit and loss account of the individual concern, marks a great advance.

The second recommendation to which Sir George directs attention relates to the need for dealing with the problem of restoration on a systematic and comprehensive scale to avoid the serious risk of creating extensive areas of broken and barren land by quarrying ironstone over large new areas. Sir George Gillett considers that this touches on one of the vital problems of the Special Areas, and that the recommendations should be extended to apply to all industries, such as the coal, chemical and brick industries, which are apt to leave scars on the landscape, and he suggests that the tragic relics of the past should be avoided by a system of compulsory insurance or by putting responsibility for clearance on the industry as a whole.

As Sir George Gillett points out, the ideal solution is for new industries to be established on sites which have already been scarred and spoilt for any but industrial purposes, as in the huge new steel works

being erected by Richard Thomas and Co. on the site of the old works at Ebbw Vale and the new steel works to be erected on the site of the old works at Palmer's Yard in Jarrow. These examples in themselves sufficiently indicate one way in which the problems of the Special Areas are linked up with those of the preservation of amenities generally, but the North Eastern Trading Estate at Team Valley provides a conspicuous example of the way in which industrial development in a new area can be planned so as to add to, rather than detract from, the amenities of the district. Already it appears that proper facilities for manufacture, pleasant conditions for labour and the high advertising value of a well-planned estate weigh quite as heavily with industrialists as economic considerations. Even if the proximity of a fine type of labour has been a further factor, there is still evidence of a real desire on the part of many industrialists to assist in the solution of the problems of this particular Area.

The Commissioner in his report does not hide the difficulties that remain to be overcome or the seriousness of the present situation, but the keynote of the present report is a definite but restrained optimism. During the twelve months, unemployment in the Areas has fallen by 25·6 per cent., of which only a comparatively small part was due to transference out of the Areas, the corresponding figure for the rest of England and Wales being 12·0 per cent. National and international causes have undoubtedly been responsible for most of this improvement, but it has been largely independent of armament work. Another encouraging sign of progress in the Durham and Tyneside Special Area, for example, is the extent to which much of the work necessary for the recuperation of the Area is now in the hands of bodies locally administered and having a lease of life which is independent of Special Area legislation. Further reduction in the volume of unemployment depends upon the success of the measures now being adopted to induce new industries to establish themselves, the further development of those measures and the policy of the Royal Commission.

As regards particular measures, the report refers once more to the question of establishing a calcium carbide factory in South Wales, the investigation of schemes for low-temperature carbonization or hydrogenation of coal, the improvement of communications, and the research carried out by the Technical Advisory Committee of the North East Development Board, while the Commissioner for the Special Areas in Scotland lays a good deal of stress upon the utilization of coke-oven gas as well as the establishment in the Area of one or other processes for the extraction of oil from coal, if any impression is to be made on the most intractable problem—that of continuing unemployment in the coal industry.

For the future, Sir George Gillett insists that it is not so much new organizations that are wanted as twelve months of steady work to see if, with the powers already granted, any impression can be made on the 200,000 unemployed men and women still left in these Areas, of whom about 80,000 are men of forty-five years of age and upwards, many suffering from diseases contracted through working in the coal mines. This is the most significant problem of the Areas, and is being tackled in various ways, apart from insisting on the employment of older men in wage-paid schemes, such as group holdings, subsistence production, voluntary (local amenities) schemes and allotments.

The problem of the Scottish Special Areas is essentially different in the greater difficulty of transference, in the absence of an expanding industrial centre in Scotland, and in the lesser severity of unemployment statistically. There are, however, many towns and communities with every local service, labour suitable for training and employment, attractive amenities, and a robust civic and social sense. Measures to deal with the unemployment in the coal industry have already been mentioned. Among indirect measures, the Commissioner lays stress on housing, land settlement and assistance to schemes for improving water supplies, sewerage and sewage disposal, drainage and the like.

In conclusion, in view of significant omissions in a recent book on the Special Areas, it is pertinent to point out that the present reports indicate that, up to September 30, 1937, estimated commitments, including expenditure on the Special Areas Fund, amount to £12,900,000 in England and Wales and £2,488,584 in Scotland.

Science News a Century Ago

Progress of British Railways

IN the January number of the *Civil Engineer and Architects' Journal*, under the heading "Progress of Railways", were given extracts from various newspapers referring to the state of construction, growth of traffic, etc., on some fifteen railways. Of the Eastern Counties Railway, it was said: "The works of this railway are now pushed as far as Ilford and it is confidently expected that it will be opened to that town (seven miles) next summer." As regards the Grand Junction Railway, it was remarked: "It is said that the Post Office Department have concluded a valid agreement with the Directors, which will enable the inhabitants of Liverpool after the first of May next, to receive their London letters, dispatched on the preceding evening, at eight on the following morning"; and also that "Notice has been given, that it is intended to dispatch a train from the station at Lime street, for the conveyance of pigs to Birmingham". Similar trains were to be dispatched each Tuesday, Wednesday and Thursday. On the Whitby and Pickering line, "A great increase has taken place in the tonnage amount of traffic and numbers of passengers conveyed, the increase in the number of passengers during the half-year had been 8,000, and the increase in goods traffic 6,000 tons". Another notice said, "On the 1st of January, the London and Birmingham Railway will be open as far as Stony Stratford, and also the Birmingham end as far as Rugby, making in the whole 77 miles of this great undertaking completed." The Bolton and Preston Railway had been decided upon, while at a meeting at Penrith of the promoters of the Lancaster and Glasgow Railway, one speaker, when alluding to the western line over Morecambe Bay to Whitehaven, declared that Mr. Stephenson had made a mistake of fourteen miles in computing the length of the line!

Visions of the Extension of the Electric Telegraph

ON January 5, 1838, a correspondent "Inquisitivus" wrote to the editor of the *Mechanics' Magazine* about the electric telegraph, which was then engaging much attention. "It is too often the case", he said, "that

the ingenuity and valuable time of talented men are wasted upon what has, unknown to them, been invented before; and of this we have instances in the electric telegraph." After referring to the telegraphs of Alexander, Ritchie, Gauss, Cooke, Wheatstone and Davy, he went on: "Now, Mr. Editor. What shall hereafter prevent our globe from having sets of wire laid down branching in all directions over its surface like the nervous system of the human body, and thus having as it were but one pervading soul?" A patient, in India, he said, could then obtain advice from a doctor in London; the *Sydney Gazette* might contain the proceedings of the House of Commons the day before. "From New York to Pekin, from Pole to Pole, man will be enabled to converse with man, as though he were in the same house, in the same chamber; it will be one step towards making all nations as one family."

Hooker's "Icones Plantarum"

SIR WILLIAM JACKSON HOOKER (1785–1865), the celebrated botanist, had among other works published "Musci Exotici", "Flora Scotica", "Icones Filicum" and his "British Flora", when in 1837 he began the publication of his "Icones Plantarum" containing figures and descriptions of rare plants in his herbarium. Speaking of the last of these, the *Athenæum* of January 6, 1838, said: "This work appears occasionally in parts, each containing fifty plates of new and rare plants, drawn on stone with singular taste and fidelity. Two volumes have appeared, and a third is announced, although it is known to the friends of the author that each volume leaves him a considerable loser. Such a fact . . . is not very creditable to the science of this country. Nothing can be more interesting to a man of science than the plants represented in these volumes; nothing can be in better taste or more faithful than the figures; and it is difficult to conceive how anything can be cheaper (fifty plates for fifty shillings): yet while the most miserable trash that the press produces under the name of Botany sells in hundreds and thousands of copies, such a sterling work as this is only enabled to maintain its ground by aid of the purse of its author. We do trust that the friends of Botany will bestir themselves on this occasion, and come forward with such a demand for copies as will, we do not say encourage, but enable, the learned author to produce many volumes in addition to those which have hitherto appeared."

The Society of Arts

THE *Mechanics' Magazine* of January 6, 1838, said: "The Society of Arts, in years gone by, took a prominent part in the scientific world, and effected considerable good in promoting that spirit of invention and discovery which is now so general among the manufacturing community. It has not, however, kept pace with the times, and has of late fallen into obscurity. It has also fallen into debt, and an appeal has been lately made to its members, urging them to procure donations and annual subscriptions from noble and wealthy patrons of the arts, manufactures and commerce of the country, and to obtain an increase in numbers so as to renovate the funds and extend the useful powers of the Society."

The appeal was issued by the secretary, Arthur Aiken (1773–1854), a chemist and mineralogist who in 1807–14 had published a "Dictionary" of those sciences.

Societies and Academies

Dublin

Royal Irish Academy, November 30.

ARTHUR E. J. WENT: The salmon of the River Shannon. An account is given of the analysis of the stocks of salmon in the River Shannon during the year 1927. The phenomenon of growth in fresh water in the year of migration as a smolt is discussed, and it is suggested that a minimum size is necessary before the physiological condition is attained which causes the assumption of the smolt livery and the smolt migration. Examination of the scales and data from smolts confirmed the results obtained from the examination of the scales of adult fish.

Paris

Academy of Sciences, November 15 (*C.R.*, 205, 885–939).

ROBERT ESNAULT-PELTERIE: The coefficient of self-inductance of a solenoid.

A. PFLUGER: The growth and distribution of the zeros of certain integral functions of positive finite order.

GEORGES VALIRON: A criterion of normal family.

JOHN ELLSWORTH: Photometric study of the variable star *BD*−1° 1004. This star is probably not a variable with eclipses. The photometric period found has no relation with the spectroscopic period.

BERNARD LYOT: The passage of Mercury across the corona.

MIRCEA DRĂGANU: The passage of very rapid protons through matter.

THÉODORE KAHAN: The phenomenon of quantum exchange and nuclear isomerism. A new method of determining this.

GUSTAVE RIBAUD: Improvements in the technique of measuring the temperatures of flames. Modifications of the Kurlbaum optical method.

J. BETHENOD: A method for testing high-power circuit breakers for high-tension systems.

MME. IRÈNE MIHUL and CONSTANTIN MIHUL: The reflection in the atmosphere of waves of radio-diffusion.

MAURICE PARODI: The transmission of some oxides in the extreme infra-red.

ANDRÉ POIROT and MAURICE AUCLAIR: The anode rays of some heavy metals, especially lead. Lead bromide placed in the discharge tube gives satisfactory results and is more convenient than the lead tetramethyl hitherto employed.

ALFRED SILBERSTEIN: Some bromocupric complex compounds.

JACQUES BÉNARD: The parameter of pure ferrous oxide.

C. F. GOODEVE and F. D. RICHARDSON: The existence of chlorous anhydride. Criticism of a recent paper on this subject by Kantzer. This author's method gives an oxide with a spectrum identical with that of chlorine dioxide.

ALEXANDRE TRAVERS and ROBERT DIEBOLD: The mechanism of the decomposition of pure cementite by acids. From a discussion of this reaction it is concluded that it is impossible to determine cementite chemically in a ferrous metal by selective solution of the iron: the carbide is always attacked, liberating carbon, and giving gaseous hydrocarbons.

PAUL CORDIER: The condensation of acetone with phenylpyruvic acid.

MAXENCE MEYER: The synthesis of a derivative of oxyhydroquinone.

RENÉ HAZARD, JEAN COMANDON and PIERRE DE FONBRUNE: The crystallization of ecgonine silicotungstate. Cinematographic registration.

ALEXIS LAMBERT: Discovery of the Rhetian with *Avicula contorta* in the Djurdjura chain.

JEAN SAGATZKY and ROSTISLAV GOLOUBINOW: The origin of the gold on the Guinea-Sudanese border and in the old Haute-Volta.

EMILE MIRGE: Chemical composition of *Triticum*, of *Ægilops* and their hybrids.

MARC SIMONET: New pentaploid hybrids in the garden *Iris* (*I. germanica*).

PAUL CHABANOUD: A new teleostean of the Solidae family, *Pseudaustroglossus annectens*.

ROGER NETTER and MLLE. SIMONE ROCHE: The action of hydrochloric acid upon insulin.

MARC DE LARAMBERGUE: Genetic study of *aphallie* in *Bulinus* (*Isodora*) *contortus*.

Brussels

Royal Academy (*Bull. Classe Sci.*, 23, Nos. 8–9, 1937).

G. GOETHALS: The synthesis of △ 2–6 octadiene-1-al. This aldehyde was prepared from pentenyl chloride by converting it into pentenyl vinyl carbinol and acting on the latter with phosphorus tribromide. Octadienyl benzoate was prepared from the bromide and then saponified. The octadienol so produced gave the octadienal on oxidation with chromic acid. The Raman spectra of the primary and secondary bromides formed in the above reactions were examined as a means of identifying the products.

B. RUYSSEN and E. VERSTRAETE: Complex coacervation of the system gelatine-saponin. Determinations of the viscosities of mixtures of these colloids as a contribution to the study of complex coacervation, an intermediate stage in the flocculation of hydrophilic colloids in which the initial desolvation is caused by the opposition of the electrical charges on the two components of the mixture.

J. D. H. DONNAY: Morphology of apophyllite. A discussion of the true crystallographic symmetry of this mineral and its representation.

Cracow

Polish Academy of Science and Letters, November 8.

S. DOBINSKI: The adsorption of the components of a solid phase at the surface. The examination, by means of electron diffraction, of the surface structure of certain metallic alloys, shows that the concentration of the components in the neighbourhood of the surface is not identical with that corresponding to the deeper layers. This is possibly due to the effect of surface tension.

J. WESOLOWSKI: The dielectric polarization of liquid selenium. From experimental results obtained with an apparatus capable of measuring the dielectric constant with an accuracy of $\pm 0{\cdot}5$ per cent, between temperatures ranging from 237° C. and 300° C., it is shown that the atomic polarization is 12·0, is independent of the temperature, and satisfies the rule established by Cuthbertson and Doborzynski.

MLLE. L. STANKIEWICZ: The arithmetical operations in the calculation of determinants according to Cracovian methods.

A. CHROMINSKI: The application of Cracovians to the rapid solution of various problems of practical analysis.

M. CENTNERSZWER and MLLE. J. BOROWICZ: Study of the electrolysis of colloidal solutions of silver.

K. DZIEWONSKI and P. TRZESINSKI: Study on pyrene (II). The preparation and properties of propionylpyrene.

W. FRIEDBERG: Catalogue of the collection of Miocene molluscs of Poland.

W. FRIEDBERG: An attempt at a stratigraphy of the Miocene of Poland, based on the molluscan fauna.

J. ZACWILICHOWSKI: The second filial generation (F_2) descendant of *Lymantria dispar*, made artificially darker.

MLLE. H. GAJEWSKA: The microscopic structure of the middle intestine of *Mesidothea entomon*.

P. PAUTSCH: Researches on the autoplastic transplantation of the tails of tadpoles of *Rana temporaria* with inversion of the dorso-ventral and cephalo-caudal axis.

Moscow

Academy of Sciences (*C.R.*, 16, No. 5, 1937).

G. AMBARZUMIAN: Distribution curves of probabilities which reproduce at their limit the Pearson distribution curves.

S. I. WAWILOW (VAVILOV): A method for the determination of the true fluorescence polarization of solutions at high concentrations.

S. I. WAWILOW (VAVILOV), P. G. GLUCHOW and I. A. KHWOSTIKOW: Fluorescence depolarization of solutions at high concentrations.

V. FABRIKANT and I. CIRG: Probability of a stepwise excitation of mercury atoms.

S. N. RŽEVKIN: The problem of the wave-field of a piezo-quartz radiator.

P. P. LAZAREFF and E. V. DOBROVOLSKAYA: Influence of singing on adaptation in peripheral vision.

D. I. MIRLIS: Kinetics of wetting and linear corrosion of metals in polyphase systems: metal-liquid-liquid and metal-liquid-gas (4).

V. G. TRONEV and C. M. BONDIN: Solubility of noble metals at high pressure. (2) Solution of gold in cyanides at atmospheric pressure.

L. P. BRESLAVEC and E. ZAUROV: Hermaphrodite hemp found in field crops.

(*C.R.*, 16, No. 6, 1937.)

N. MOISSEIEV: Stability and anti-stability of the third generalized type.

NATALIE REIN: Method of evaluation of the period of solution of a problem restricted to three bodies.

S. BELLUSTIN: Influence of space charge on a current in vacuum.

W. W. SHOULEJKIN: Theory of monsoons. (2) Vertical distribution of velocities.

S. A. BOROVIK and T. A. BUROVA: Quantitative spectroscopic determination of neodymium and praseodymium in minerals.

V. G. TRONEV and S. M. BONDIN: Solubility of noble metals at high pressure. (3) Influence of temperature and of the potassium cyanide concentration on the rate of solution of gold at high pressure.

V. G. TRONEV: Displacement of gold in chloride solutions by hydrogen at high pressure.

B. K. KLIMOV and E. I. KAZAKOV: Carotene (provitamin A) in sapropel.

M. G. TUMANIAN: Occurrence in Nature of polyploid mutations in wild monococcal wheat.

J. W. R. RAKITIN: Flower-bud drop in some varieties of the cotton plant under the influence of different lengths of day.

K. ARNOLDI: Life forms in ants.

L. N. ZHINKIN: Experiments on the reversion of polarity during regeneration in *Lumbriculus variegatus* Müll.

VERA GROMOVA: New finds of Late Pleistocene fauna in North Caucasus.

(*C.R.*, **16**, No. 7, 1937.)

V. V. ČELINCEV: Furfurylidene- and benzylidene-phenol systems and their fusibility diagrams.

A. D. GELMAN: Compounds of platinum with unsaturated hydrocarbons of the ethylene series.

D. P. SERDIUČENKO: The isomorphic series kerolite-beidellite in argillaceous silicates.

A. N. ADOWA and I. A. SMORODINZEW: Oxido-reduction potential during the pepsin digestion of proteins.

N. I. MAKOVNIK: A new tungsten-bearing region in the U.S.S.R.

T. N. AGAFONOVA: Quantitative mineralogical X-ray analysis.

G. N. VERTUŠKOV: Alpine type veins in the Urals.

A. NIKONOV: Stratigraphy of the sources of the Katun River in the Altai Mountains.

I. N. KONOVALOV: An experiment in vernalizing the embryos of wheat seeds without endosperm.

Washington, D.C.

National Academy of Sciences (*Proc.*, 23, 535–559, Oct. 15, 1937).

C. C. LITTLE and A. M. CLOUDMAN: Occurrence of a dominant spotting mutation in the house mouse. A new mutation has been found, probably an allele of the dominant spotting already known and more viable in the homozygous condition.

E. W. BERRY: Succession of fossil floras in Patagonia. Following the Late Jurassic cosmopolitan floras, conditions during Lower and Upper Cretaceous did not prevent colonization by elements representing Upper Cretaceous flowering plants. Early in the Tertiary, a change occurred which allowed a flora of small-leafed and largely beech forest (Eogene) to extend down to Antarctica.

B. H. WILLIER, MARY E. RAWLES and E. HADORN: Skin transplants between embryos of different breeds of fowl. Skin ectoderm (0·5 mm. × 1 mm.) was taken from the dorso-lateral surface of the head, freed from mesoderm, and inserted, through a window cut in the shell of another egg, at the base of the right wing or the leg bud; both donor and host were incubated for about 75 hours. The embryos were examined when 15 days old, when they have well-developed down feathers. Black skin grafts give a patch of black feathers, but white skin grafts on a black breed have no apparent effect. It seems that skin ectoderm is dependent on the position on the host for the form of feathers produced, but as regards colour, the feathers are dependent on the genic constitution of the graft.

A. D. MICHAL: General projective differential geometry.

G. A. MILLER: Groups in which every sub-group of composite order is invariant.

H. S. VANDIVER: (1) The concept of co-sets in a semi-group. (2) Generalizations on the numbers of Bernoulli and Euler.

Forthcoming Events

Friday, January 7

ENGINEERING PUBLIC RELATIONS COMMITTEE (at the Institution of Electrical Engineers), at 3.—Prof. C. E. Inglis, F.R.S.: "Building Big Bridges" (Christmas Lectures for Young People. Succeeding lecture on January 10).

CONFERENCE OF EDUCATIONAL ASSOCIATIONS, January 3–10. To be held in University College, London.

The Right Hon. Sir Kingsley Wood, M.P.: "Education and Health" (Presidential Address).

GEOGRAPHICAL ASSOCIATION, January 4–6. Annual Conference to be held in the London School of Economics.

January 4, Prof. Patrick Abercrombie: "Geography, the Basis of Planning" (Presidential Address).

ANNUAL EXHIBITION OF SCIENTIFIC APPARATUS BY THE PHYSICAL SOCIETY, January 4–6. To be held at the Imperial College of Science and Technology, London.

Discourses:

January 4, Capt. G. C. C. Damant: "Diving in Deep Water and Shallow".

January 5, Prof. A. F. C. Pollard: "Mechanisms for Measuring Small Changes".

SCIENCE MASTERS ASSOCIATION, January 4–7. To be held in the Chemistry Department of the Imperial College of Science and Technology, South Kensington, S.W.7.

January 4, Sir Cyril Ashford: "Past and Future Aims of School Science" (Presidential Address).

January 5, Sir Richard Gregory, Bt., F.R.S.: "Science and Citizenship".

Appointments Vacant

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:

ASSISTANT LECTURER IN AERONAUTICS in the Imperial College of Science and Technology, Prince Consort Road, S.W.7—The Secretary (January 7).

RESEARCH CHEMIST (subsidiary subjects physics or metallurgy) for the Northern Coke Research Committee—Secretary, Northern Coke Research Committee, King's College, Newcastle-on-Tyne.

Official Publications Received

Great Britain and Ireland

Edinburgh Geological Society. Geological Excursion Guide to the Assynt District of Sutherland. By Dr. M. Macgregor and Dr. J. Phemister. Pp. 62+4 plates. (Edinburgh: Edinburgh Geological Society.) 2s. [1911

Air Ministry: Aeronautical Research Committee: Reports and Memoranda. No. 1741 (2361): Full Scale Lift, Drag and Landing Measurements of a Monoplane fitted with a Zap Flap. By E. T. Jones, J. Cohen and P. A. Hufton. Pp. 27. 4s. net. No. 1758 (2499): The Vibration of Airscrew Blades with particular reference to their Response to Harmonic Torque Impulses in the Drive. By B. C. Carter. Pp. 37. 5s. 6d. net. No. 1770 (2589): The Behaviour of a Pitot Tube in a Transverse Total-Pressure Gradient. By A. D. Young and J. N. Maas. Pp. 16. 2s. 6d. net. No. 1775 (2724): The Experimental Determination of the Bending Actions induced by Axial End Constraints in a Rectangular Tube in Torsion. By D. Williams and C. B. Smith. Pp. 19. 3s. net. No. 1776 (2552): Note on the Directional Stability of Seaplanes on the Water. By Dr. J. P. Gott. Pp. 14. 2s. net. No. 1777 (2664): Effect of Differences of Form on the Porpoising Characteristics of Two Flying Boats. By L. Johnston and W. D. Tye. Pp. 10. 1s. 6d. net. No. 1778 (2806): Note on the Standardisation of Pitot-Static Head Position of Monoplanes. By S. B. Gates and J. Cohen. Pp. 14. 2s. net. No. 1780 (2956): Diffusion of Concentrated Loads into Monocoque Structures. By H. L. Cox, H. E. Smith and C. G. Conway. Pp. 16. 2s. 6d. net. (London: H.M. Stationery Office.) [1911

Other Countries

J. E. Purkinje: Commentatio de examine physiologico organi visus et systematis cutanei, Vratislaviae 1823. Quam pro loco in Gratiosa Medicorum Ordine. By Guilelmo Kraus. Pp. 58. ('s-Gravenhage: Dr. W. Junk.) 8 guilders. [1911